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JPRS-CEA-84-026

9 April 1984

# China Report

ECONOMIC AFFAIRS

ENERGY: STATUS AND DEVELOPMENT -- XXVI

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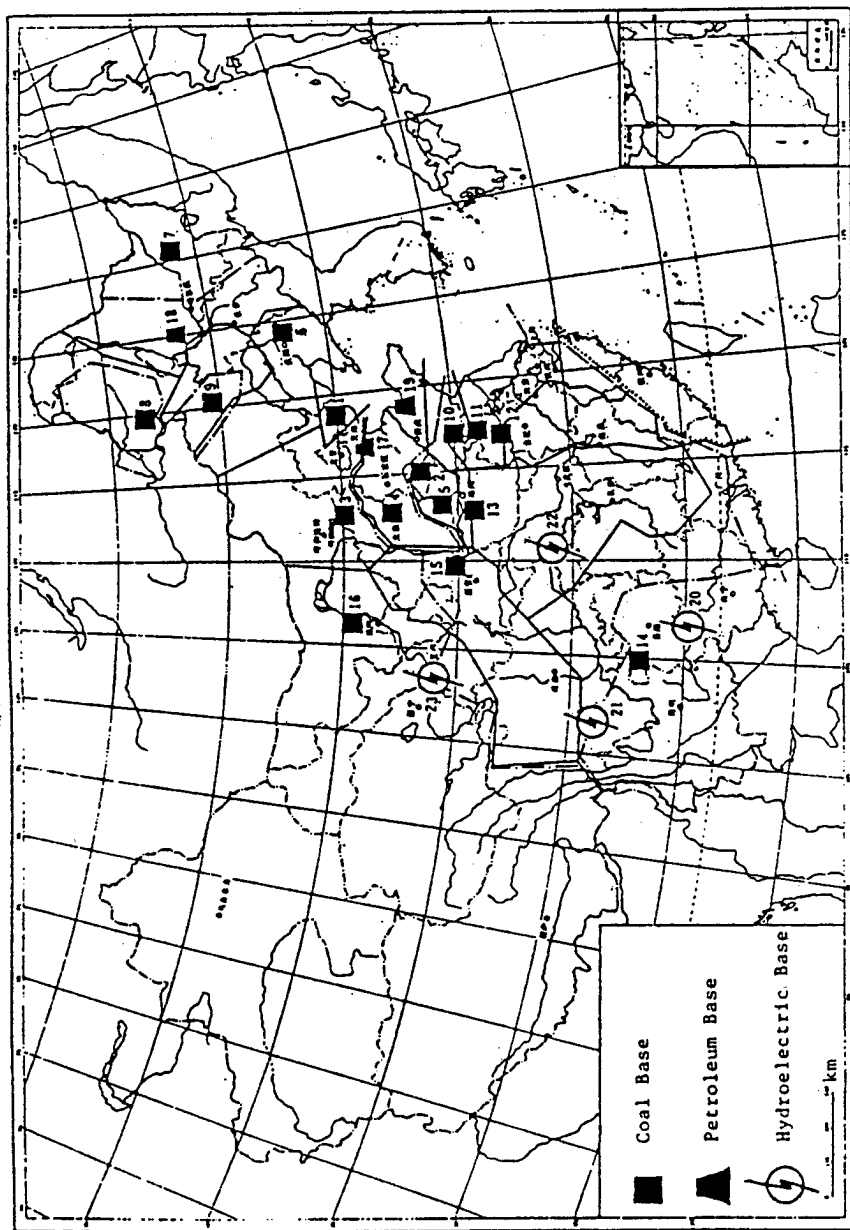


Fig 1 Distribution of main energy bases and marketing regions of coal bases in China

— Rational boundary of Coal Base Supply.

--- Rational boundary of supply of large coal bases in northern, central and southeastern Shanxi.

..... Rational boundary of supply by sea of Shandong coal.

1. Eastern Hebei, 2. Southern Hebei and northern Henan, 3. Northern Shanxi and southern Nei Monggol, 4. Central Shanxi, 5. Southwestern Shanxi and northwestern Henan, 6. Liaoning, 7. Eastern Heilongjiang, 8. Yiminhe, 9. Huolinhe, 10. Southern Shandong, 11. Anhui and Jiangsu, 12. Southern Anhui, 13. Western Henan, 14. Western Guizhou, 15. Northern Shanxi, 16. Helanshan and Zhuozishan, 17. Northern China, 18. Daqing, 19. Shengli, 20. Southern system, 21. Southwest system, 22. Central system, 23. Northwest system

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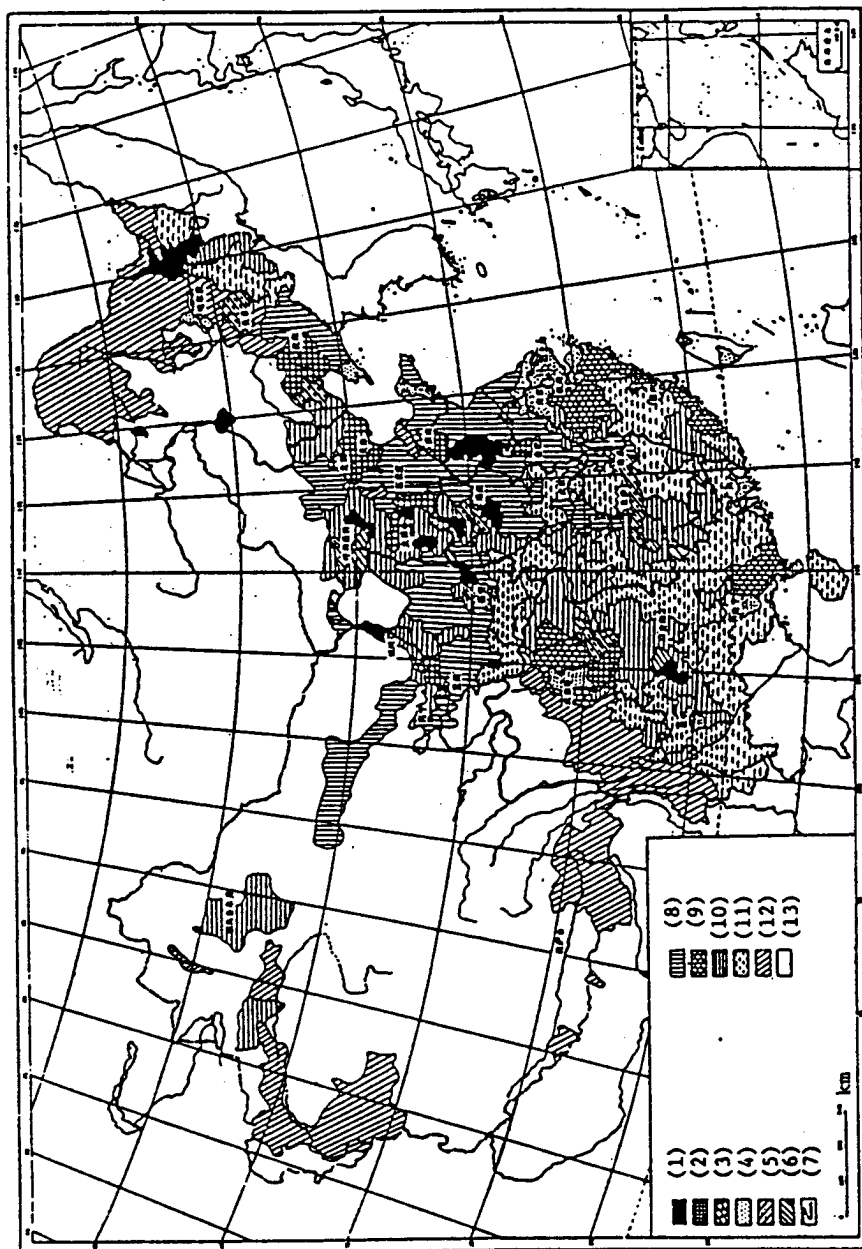


Fig 2 Proposed energy-economic regionalization of China

Key: 1) Coal development and export; 2) Energy-industry integrated development; 3) Processing industry and energy production; 4) Highly developed industrial zone far from energy sources; 5) Oil development; 6) Long-term energy development; 7) First-order energy-economic regions; 8) Methane; 9) Methane and small-scale hydropower; 10) Local coal; 11) Small-scale hydropower; 12) Firewood; 13) Livestock breeding.

9 April 1984

## CHINA REPORT

### ECONOMIC AFFAIRS

#### ENERGY: STATUS AND DEVELOPMENT -- XXVI

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## NATIONAL POLICY

### SINO-U.S. SYMPOSIUM ON NUCLEAR POWER STATIONS HELD IN KUNMING

Beijing DIANLI JISHU [ELECTRIC POWER] in Chinese No 11, 5 Nov 83 pp 80-81

[Text] The Sino-U.S. Symposium on Nuclear Power Stations was held from 23-29 July at the Yunnan Science and Technology Hall in Kunming. The Symposium was chaired by Jiang Shengjie (1203 5110 7132), the chairman of the Science Committee of the Ministry of Nuclear Industry and the deputy director of the Chinese Nuclear Association. There were 33 Chinese delegates at the Symposium representing the following organizations: the Ministry of Nuclear Industry, the Southwest Reactor Design Institute, the Beijing Nuclear Engineering Design Institute, the Office of Intelligence of the Ministry of Nuclear Industry, the Qinshan Nuclear Power Station, the Suzhou Nuclear Power Station of the Ministry of Water Resources and Electric Power, the Office of Intelligence of the Ministry of Machine Building, the Huadong Energy Research Committee, Jiaotong University of Shanghai, Qinghua University, and electric power financial committees and departments of six provinces (Fujian, Jiangsu, Jiangxi, Liaoning, Jilin, and Heilongjiang) and three cities (Shanghai, Dalian, and Jiujiang). There were seven U.S. representatives including vice president Bray, the technical director and department heads of the General Electric Company, as well as engineer Hughes.

Comrade Jiang Shengjie first gave a report on the current status and future prospect of China's nuclear energy development. Highlights of this report are summarized below:

1. China's goal is to quadruple the overall agricultural and industrial output value by the year 2000. Preliminary estimates indicate that the energy requirement to match this rate of growth is approximately 1.3-1.4 billion tons of standard coal; in other words, the total output of energy in the year 2000 will be slightly more than double the output in 1980. But the rate of growth of power generation must keep up with industrial growth, i.e., it must also quadruple.
2. China's energy distribution is highly uneven; 61 percent of the coal reserves are concentrated in Shanxi and Nei Monggol, whereas the southeast provinces and the Shanghai region only have 1.6 percent of the reserve. Seventy-one percent of the hydropower resources are concentrated in China's southwest region, 11 percent are found in the northwest region. The southwest provinces and the Shanghai region have 5 percent of China's petroleum resources.

3. China's nuclear energy policy. The heavy demands for energy are in the industrialized provinces along the coast. However, the energy resources in these regions are quite limited; they must be transported from other locations. Due to the limited transportation capability, there has always been a shortage of energy supply in these regions. Since the transportation problem is not likely to be resolved in the foreseeable future, an effective way to ensure adequate energy supply is to construct nuclear power stations along the coastal regions. During the next 10 to 20 years, China plans to develop its own nuclear power generation capability in the range of 10,000 megawatts. But we are also considering importing a number of nuclear stations. Within the next few years we plan to import nuclear power stations in the range of hundreds of megawatts or even 2000-3000 megawatts. However, such decisions can only be made under favorable trade conditions. In addition, we also plan to build small, dual-purpose nuclear power stations to provide both heat and electric utility. Before the end of this century, we will be developing primarily pressurized-water reactors. Hopefully, we will succeed in building a 10,000-megawatt nuclear power station.

4. In addition, research work is also underway to develop new types of reactors.

Vice Presidents Bray and Williams of the General Electric Co. delivered a technical report at the Symposium; highlights of their report are summarized below:

#### 1. Nuclear Technology at the General Electric Company

For the benefit of China's nuclear development, the General Electric Co. has agreed to transfer its nuclear technology, which will include complete equipment design, engineering management, and general technologies to this country. In the development and production of boiling-water reactor nuclear power stations, the General Electric Co. has accumulated 40 years of experience in research and 25 years of experience in manufacturing and operation. Nuclear power stations produced by the General Electric Co. and currently in use around the world include: 50 in the United States, 22 in Japan, 8 in West Germany, 4 in Taiwan, and 111 others in Sweden, Spain, Holland, Switzerland, Italy, Mexico, India, Finland, and Australia. The total power generation capacity is 92,330 megawatts.

#### 2. Advantages of the Boiling-Water Reactor

(1) The boiling-water reactor is much safer than the pressurized-water reactor; there is little possibility of core meltdown. The reason is that in a boiling-water reactor, cooling water is injected directly into the reactor; in case trouble develops in the reactor, large amounts of water can be pumped in to cool down the core. The boiling-water reactor is also equipped with surface gauges and 13 high and low pressure pumps; its cooling efficiency is much higher than that of pressurized-water reactor. It is the opinion of General Electric Co. that a boiling-water reactor power station can be safely located near an urban area with people and livestock living around the station.

(2) The pressurized-water reactor uses control rods to adjust the load, which is limited to a range of 3-4 percent. The boiling-water reactor on the other hand only uses control rods for load adjustment during start-up and during normal operation, the load is adjusted by the amount of water being circulated (not by control rods), and the rate of adjustment is 1 percent per second.

(3) The basic difference between the structures of boiling-water reactor and pressurized-water reactor is the following. The pressurized-water reactor is quite large in size because it has 2-3 steam generators which indirectly supply steam to the turbines; under normal conditions the steam does not contain any radioactive substances. In a boiling-water reactor, however, steam produced by the core is directly supplied to the turbines. In order to prevent radioactive particles from entering the turbines, the reactor is equipped with dryers and purification devices. Through design improvements of these devices over the years, the radiation level in the turbines is now only 1-2 percent that of the rest of the power plant. The steam systems of modern boiling-water reactors all have bleeding equipment. By using the process of regeneration, condensation and filtering through an active charcoal bed before exhausting into the atmosphere, the radiation level of steam from a boiling-water reactor can be reduced to less than 0.1 curie per second. With bleeding equipment, the radiation level can be further reduced to 10-100 millicurie per second, which is within the specified safety standards. (4) In recent years, the General Electric Co. has been using SS316NG stainless steel pipes to avoid corrosion and cracks in the pipe walls due to bombardment by radioactive neutrons in the steam. But the seals in the water pumps must still be replaced every year. In case of the pressurized-water reactor, due to brittleness at low temperatures, the steam generator must be completely overhauled every 7 years.

After 2 days of active discussions, the major concerns of China's representatives were removed as they unanimously agreed that significant improvements have been made by the General Electric Co. to achieve safe operation of the boiling-water reactor. They were also convinced that building and using boiling-water reactors in this country is quite feasible because of their simplicity, safety and rapid load adjustment capability.

### 3. Financial Issues and Construction Cycle

(1) Comparison of construction cost between a 984,000 kW boiling-water reactor power station and a pressurized-water reactor power station (based on all contract work at July 1982 cost).

	Boiling-water reactor (millions of U.S. dollars)	Pressurized-water reactor (millions of U.S. dollars)
Direct investment	777	785
land	3	3
construction and improvement	226	207
reactor	224	253
turbines	192	188
electrical equipment and associated structures	78	77
auxiliary equipment and associated structures	22	24
condensation equipment and systems	32	33
Indirect investment	448	447
architectural service	92	90
office building and facilities	180	180
field engineering cost	60	61
party A expenses	116	116
unpredictable expenses	122	123
Total investment	1347	1355

(2) Comparison of the cost to produce 1 kWh of electricity of nuclear power plant, coal-burning power plant and oil-burning power plant (unit: .1 U.S. cent)

	nuclear power	coal power	oil power
Investment depreciation	24	19	
operation maintenance cost	3	6	
fuel cost	6	16	
Total	34	42	55

(3) Construction schedule with party B under full contract

(A) Signing of the contract on 1 January of the 1st year.

(B) Construction of the reactor shell of the first unit will begin in early October of the 1st year and will be completed at the end of November of the 5th year; construction of the reactor shell of the second unit will begin in early September of the 2nd year and will be completed at the end of September of the 6th year.

(C) Installation of the reactor equipment of the first unit will begin in early July of the 2nd year and will be completed at the end of February of the 6th year; installation of reactor equipment of the second unit will begin in early August of the 3rd year and will be completed at the end of the 6th year.

(D) Auxiliary construction will begin in early December of the 1st year and will be completed at the end of September of the 4th year. Equipment installation of the first unit will begin in early May of the 3rd year and will be completed at the end of the 5th year; equipment installation of the second unit will begin in the early part of the 4th year and will be completed at the end of the 6th year.

(E) Construction of the fuel building will begin in early March of the 2nd year and will be completed at the end of May of the 5th year. Equipment installation will begin in early June of the 3rd year and will be completed at the end of August of the 6th year.

(F) Construction of the main control building will begin in early June of the 3rd year and will be completed at the end of the 4th year; equipment installation will begin in early April of the 4th year and will be completed at the end of the 5th year.

(G) Construction of the turbine room will begin in early March of the 2nd year and will be completed at the end of the 4th year; equipment installation for the first generator unit will begin in early April of the 3rd year and will be completed at the end of April of the 5th year, the second unit will begin in early December of the 3rd year and will be completed at the end of the 6th year.

(H) Other construction work will begin in early March of the 2nd year and will be completed at the end of November of the 5th year; equipment installation will begin in early August of the 2nd year and will be completed at the end of August of the 6th year.

The entire project will be completed 6 years after signing the contract.

#### 4. Engineering Management and Technology Transfer

The General Electric Co. believes that engineering management should be under full contract to party B. For example, the boiling-water reactor power station projects in Japan and Italy were under full contract to the General Electric Co. during the initial phase; later, part of the work was taken over by the host

countries. The U.S. delegates feel that during the initial phase, partial contracting to both parties is undesirable because it may adversely affect project schedule and quality. In particular, the U.S. will not consider using party A workers during the phase of technology transfer and personnel training. During negotiations, Chinese delegates pointed out that China has much lower labor cost and is capable of performing certain aspects of the construction work. In the interest of conserving China's foreign exchange, the U.S. representatives agreed to consider other engineering management methods to be used in this country.

Once a national plan for developing nuclear power stations is finalized, preparation work should get underway; in addition, an overall plan for learning the technologies and training personnel must also be established in order to develop the capability for building and operating nuclear power stations.

This Symposium provided an opportunity for a healthy exchange between U.S. and Chinese delegates and undoubtedly will benefit the development of China's nuclear power industry.

3012

CSO: 4013/48

## NATIONAL POLICY

### NUCLEAR POWER DEVELOPMENT TO RELY LARGELY ON DOMESTIC EFFORTS

HK100110 Beijing CHINA DAILY in English 9 Feb 84 p 4

["Special to CHINA DAILY" by Tan Zhongan and Zhang Shiguan, senior engineers, Technical Information Institute, Ministry of Nuclear Industry: "Nuclear Industry Reaching Towards Full Development"]

[Text] China has abundant coal, plus potential water power, but its energy resources are not so great on a per capita basis. For instance, coal deposits are estimated at 600 billion tons, which is only 600 tons per capita. The energy resources are not well distributed; 60 percent of the coal is concentrated in north China, but southeastern coastal areas like Jiangsu, Zhejiang, Fujian, and Guangdong have a severe lack of energy, requiring coal to be shipped from the north. These power-short areas are eager for the development of nuclear energy.

Development of nuclear power is an important goal of China's energy policy. The percentage of nuclear power in China's total electric energy program will be decided when our long-term plan is formed. Our long-term nuclear program is still in the drafting stage.

China's basic policy for nuclear power is to rely mainly on its own efforts. It has developed the basic technical requirements.

In the early 1950's the Chinese Government engaged some scientists and engineers to start nuclear research. They focused mainly on nuclear physics and nuclear chemistry. In the late 1950's China imported a heavy water experimental reactor and began to set up a comprehensive research center, the Research Institute of Atomic Energy. The government began to establish various nuclear installations and started exploring for uranium ore in a planned way. During the 1970's, as part of research on small power reactors, it designed and manufactured pressurized-water reactors (PWR). During the early 1980's, China has strengthened the whole nuclear industry--from exploring for and extracting uranium, manufacturing nuclear fuel, developing special equipment and other related research and development activities. Several research reactors have been built and are in operation.

In 1980, a high flux testing reactor was put into operation in Sichuan Province. The main uses of this reactor are for irradiation research of fuel and materials for power reactors as well as isotope production.



We have a sound foundation for building small- and medium-size power reactors, but we have no experience in building large commercial power reactors nor the ability to manufacture a whole set of plant equipment. A lot of research and development work remains to be done even with the transfer of technology from abroad.

We are now building a nuclear power plant at Qinshan in Haiyan County, Zhejiang Province, about 100 kilometers south of Shanghai. The reactor will be a pressurized-water reactor of light water design and have a net electric output of 300 megawatts. The plant was designed by our own scientists. Site preparation has already begun. It will need about seven years to complete the project, which is expected to start operation in 1990. This is only a prototype and its main purpose is to gain experience and to train personnel.

Another plant is under construction in Guangdong Province near Hong Kong. It is operated jointly by the Guangdong Power Company and the China Light and Power Company of Hong Kong. The feasibility study report on this plant has already been approved. Some of our experts proposed that we develop a hydroelectric station on the Hongshui River in Guangxi Province instead of a nuclear plant, but it is our opinion that both must be developed at the same time.

China is now investigating with several foreign companies such things as construction costs and conditions of technology transfer. The guideline is that China must learn the technology when importing the equipment.

Also near Shanghai, the Jinshan Nuclear District and Process Heating Plant is planned. It is intended to supply heat to the Jinshan Petrochemical General Factory. Each unit should supply 500 tons of saturated steam per hour. This project is still in the design stage and approval is being sought from the government.

CSO: 4010/47

## NATIONAL POLICY

### STATE COUNCIL ISSUES REGULATIONS ON POWER DISTRIBUTION

OW310630 Beijing XINHUA Domestic Service in Chinese 1223 GMT 30 Jan 84

[Text] Beijing, 30 January (XINHUA)--The State Council recently laid down regulations on the distribution of electric power, calling for efforts to ensure that the need of key enterprises for power supply is met in order to facilitate the smooth development of the national economy.

The regulations state: It is necessary to take all factors into consideration and make overall plans and selective arrangements for the distribution of electric power. While ensuring the production of key state enterprises and the construction of key state projects, it is essential to make proper arrangements for power supply to other sectors. A power grid's new increment of power supply in a given year (excluding output of generating units newly built with funds raised by a locality or enterprise itself) should be distributed by the state in a unified way, serving mainly the production of key enterprises and trial runs and operations of newly completed key projects. The new increment of power supply should also be used for appropriately increased power supply for various provinces, municipalities and autonomous regions. Beginning from 1984, the proportion for local use of electric power supplied by generating units built with state investment should be determined according to the actual conditions of the various power grids, and the largest proportion retained for local use should not exceed 10 percent of the electric power supplies by the generating units that are put into operation that year. The state will make annual plans for the use of electric power by the various provinces, municipalities and autonomous regions, and these plans will specify the power consumption quotas for the various key enterprises as well as for the various provinces, municipalities and autonomous regions. All key enterprises as well as the various provinces, municipalities and autonomous regions should use electric power responsibly, within their quotas and in strict accordance with annual plans.

The regulations point out: Plans for the use of electric power should be made according to specific procedures. The Ministry of Water Resources and Electric Power should be responsible for organizing personnel to carry out these plans, and the State Economic Commission should supervise and inspect their implementation and coordinate efforts to solve major problems in case they arise. The power departments of the various provinces, municipalities and autonomous regions should do well their practical work in power supply and report regularly to the State Economic Commission, the State Planning Commission,

the Ministry of Water Resources and Electric Power and the Power Grid Administration on the implementation of plans for the use of electric power by the various key enterprises, provinces municipalities and autonomous regions, and the Ministry of Water Resources and Electric Power should be responsible for supervision and periodic inspection in this regard. The amount of electric power generated by power grids in excess of their plans and the amount of electric power reduced from power quotas of units that have overconsumed electric power will be distributed by the state mainly for increasing introduction by key enterprises.

The regulations state: All areas and units must use electric power in strict accordance with monthly and seasonal power distribution plans drawn up by power grids and by provinces, municipalities and autonomous regions. Any electric power they save belongs to themselves, and any electric power they overconsume will be reduced from subsequent quotas. When an area or unit refuses to have the amount of electric power it has overconsumed reduced from subsequent quotas, the relevant power department, after giving advance notice, may restrict its use of power, enforce a reduction or impose a fine on it for overconsumption of electric power. The unit that is guilty of overconsumption should be responsible for losses incurred as a result of restrictions imposed on its use of electric power, and the fine it pays should be defrayed from the portion it retains of profits or from local financial resources, not from profits that should be turned over especially for the planned or economical use of electric power, not for any other purposes.

The regulations stress: Power departments should generate and supply power strictly according to plans and install devices for fixed amounts of power consumption by key enterprises. They should ensure that electric power for key enterprises is supplied according to plans. Key enterprises may install themselves devices for fixed amounts of power consumption in order to insure a safe load and the use of electric power for main purposes, and power departments should give them support and technical guidance in this regard.

The regulations state in conclusion: Beginning from 1984, these regulations will be put to trial implementation in four power grids, the Northeast China, North China, East China and Central China power grids. Other power grids should also give priority to ensuring power supply for the production of key enterprises and the construction of key projects in accordance with state plans and tasks.

CSO: 4013/87

## NATIONAL POLICY

### FOUNDATIONS BEING LAID FOR HUGE SHANXI ENERGY BASE

OW211252 Beijing XINHUA in English 1030 GMT 21 Jan 84

[Text] Beijing, 21 January (XINHUA)--China's biggest energy base centered on Shanxi Province is being planned, the ECONOMIC DAILY reported today.

It is expected to produce an annual average of 600 million tons of coal in 2000; 360 million tons will be supplied to other parts of China or exported annually.

ECONOMIC DAILY quotes the Shanxi energy development planning office under the State Council as saying that by the end of this century, North China will receive 50 billion kilowatt-hours of electricity a year from the base which covers 500,000 square kilometers encompassing all of Shanxi Province, northern Shaanxi and western Henan and western Nei Monggol.

The base's verified coal reserves account for 60 percent of the country's total.

In addition to opening new mines and thermal power plants, the State Council plan includes:

--adopting new coal extraction methods and better technology for open-cut mining;

--renovating 9 railway trunk lines while building 8 new ones, bringing the total number in the area up to 20 and increasing the area's railway freight capacity to anywhere between 500 million to 600 million tons a year;

--building an additional 70,000 kilometers of highways to increase the length of the area's highways to 200,000 kilometers and its highway transport capacity from 300 million tons to at least 1 billion tons a year;

--developing trains able to carry loads of anywhere between 6,000 tons and 10,000 tons. At present, most Chinese trains carry loads of up to 3,500 tons.

The State Council office also plans to build more aluminum, copper, and steel mills, iron alloy plants, as well as chemical and building materials factories in the Shanxi energy base.

Environmental protection projects are also being planned for the area.

In an interview with ECONOMIC DAILY, Guo Qinan, deputy director of the office, said that construction was now proceeding smoothly on some of the key development projects.

CSO: 4010/42

## NATIONAL POLICY

### ENERGY-ECONOMIC REGIONALIZATION STUDIED

Beijing DILI XUEBAO [ACTA GEOGRAPHICA SINICA] in Chinese No 4, Dec 1983 pp 327-340

[Article by Li Wenyan [2621 2429 1750] and Chen Hang [7115 5300] of the Institute of Geography, Chinese Academy of Sciences: "A Preliminary Study on the Energy-Economic Regionalization of China"]

[Text] Economic regionalization that is based on the laws of economics and is compatible with local conditions is an important measure in the guidance of social production. Objective and practical socialist economic regionalization is useful to the formulation of the correct national economic plans and to the rational organization of local production.

The energy-economic regionalization is a regional division on a national scale. It should be based on the availability of energy resources, the coordination of production and marketing and the characteristic differences in regional structure and it should serve the rational deployment of the nation's production force in a specific period.

Since the energy-economic regionalization is based on an evaluation of the energy resources in various regions and an analysis of the energy development and supply and demand situation, and because resources, production, transportation, and consumption are given an overall consideration with the future in mind in an energy-economic regionalization, such an endeavor benefits a full understanding of the distribution of energy resources and the regional differences in the development conditions. It also helps to clarify the relationship of the energy supply in each region and the national economic structure, and thereby provides scientific basis for further improvements of the deployment of energy production in the nation, coordinating the regional balance of production and marketing and formulating energy policies and industrial development plans for the various regions.

Under the leadership of Lenin in the early 1920's, the Soviet Union was divided into power-economic regions in the Russian electrification program. This regionalization has later become the basis for a comprehensive economic regionalization. After repeated study and modification and through implementation in a series of 5-year plans, the Soviet regionalization played a prominent role in the rational deployment of the production force of Russia.

Since the revolution, the economic planning and the deployment and distribution of energy resources in China have been solely based on the departmental system and the administrative division. Inadequate attention has been paid to the characteristic distribution of resources, the formation of energy bases, the intrinsic direction of energy flow, and the laws of economics. Energy policies formed in this manner invariably brought great losses in the economy. Therefore, to achieve a rational deployment of the production force and to coordinate the energy resources with the national economic development, we must organize the production, transportation, distribution and utilization of energy and the various capital construction projects according to the energy-economic regionalization.

#### I. Regional Differences in the Degree of Guaranteed Energy Resources Are Basis for Regionalization

A prerequisite for energy-economic regionalization is a comprehensive assessment of the regional distribution of the energy resources in China. China has abundant and complete energy resources but their geographic distribution is very uneven. Each region has its unique energy structure but the degree of abundance and the development conditions vary.

Almost 80 percent of China's confirmed coal reserves are in the north, 64 percent of it concentrated in the northern region, 10 percent in the southwest and only 2 percent in the eight provinces south of the Chang Jiang. Ninety-eight percent of the confirmed oil reserves are in the north, with more than 80 percent concentrated in the northeastern region and the northern region. Sichuan has 67 percent of China's verified natural gas reserves. Ninety percent of the water resources are in the southwest, northwest, and central China. A great majority of the hydropower resources are on the main river course and the tributaries of the middle and lower reaches of the Chang Jiang, major rivers in the southwest, the Hongshui He, and the upper reaches of the Huang He. Only 10 percent are in the three large regions of the northeastern region, the northern region and the eastern region. In order to conduct a comprehensive evaluation of the regional energy resources, the first fundamental task is to compare the degree of ensurment of the energy resources in the various regions. The following five comparisons should be made in the evaluation: (1) regional energy reserve as a percentage of the national energy reserve, (2) regional structure of the energy resources, (3) abundance of energy resources in the various regions, (4) density of the regional energy resources, and (5) the degree of production and supply ensurment of energy in the various regions.

The first method is most widely used, especially in the analysis of a specific resource. But a regional comparison of all the resources involves not only the first method but also the basic computation methods for (2), (3) and (4) listed above. All the calculation methods used in China and abroad convert mineral fuels into standard coal, but there is no uniform computation method for hydropower. In this paper we propose a computation method in which the thermo-electric power production coal consumption of 350 grams of standard coal per kilowatt-hour is multiplied by 100 years and the hydropower reserve is added to mineral fuels. In this computation China's theoretical energy resources amount to 681 billion tons of standard coal. The calculated total energy, expressed as a percentage of the national total, and the composition of energy resources for the six large regions in China are listed in Table 1.

Table 1 Some basic facts of the regional energy resources

		Percentage of national total				Composition(%)			Abundance (ton/person)
		Total energy	Coal	Hydro	Oil,gas	Coal	Hydro	Oil,gas, shale	
Economic cooperative regions	Northern	43.9	64.0	1.8	14.4	98.2	1.3	0.5	2680
	Northeastern	3.8	3.1	1.8	48.3	54.6	14.2	31.2	293
	Eastern	6.0	6.5	4.4	18.2	72.9	22.5	4.6	141
	Central south	5.6	3.7	9.5	2.5	44.5	51.8	3.7	142
	Southwestern	28.6	10.7	70.0	2.5	25.2	74.7	0.1	1218
	Northwestern	12.1	12.0	12.5	14.0	66.7	31.3	2.0	1216
First-order energy-economic regions	Northern	36.0	52.0	1.4	32.1	97.4	1.2	1.4	1710
	Northeastern	7.9	9.1	2.2	48.3	76.5	8.6	14.9	554
	Eastern	5.0	5.8	3.6	0.5	78.7	21.2	...	148
	Central	8.8	9.9	6.7	2.4	76.2	23.4	0.4	294
	Southern	21.1	11.1	44.0	2.6	35.4	63.6	1.0	596
	Western	21.2	12.1	42.1	14.0	38.4	60.5	1.1	2067

- Notes 1. Coal and oil shale figures are based on confirmed reserve as of the end of 1980, oil and natural gas figures are based on original geological reserves as of the end of 1980, hydropower figures are based on theoretical reserve from the 1979-80 survey, multiplied by 100 years.
2. Standard coal conversion: coal 0.714ton/ton, oil 1.43ton/ton, natural gas 1.33ton/1000m<sup>3</sup>, oil shale 0.143 ton/ton. Hydropower based on the consumption of 350 g/kWh of thermopower production.
3. Population figure based on 1980 statistics.



The national and regional energy resources divided by the population are the theoretical per capita reserve. This is used as an indicator of the abundance of the energy. Our calculation shows that the national per capita energy reserve is 693 tons of standard coal. As can be seen from Table 1, the three regions low on energy resources are the eastern region, the northeastern region and the central south region, with a combined energy reserve of only 15 percent of the national total. In the eastern and central south regions the per capita energy reserve is only 140 tons of standard coal because of the high population density. In terms of providences and regions, if we consider 1,000 tons or more of per capita energy reserve as rich, 300-1,000 tons as medium, 100-300 tons as low, and less than 100 tons as poor, then Shanxi, Nei Monggol, Guizhou, Yunnan, Qinghai, Xinjiang, Ningxia and Xizang are rich provinces and regions and the eight provinces south of the Chang Jiang and the coastal provinces of Shandong, Hebei, Liaoning, Jilin and Henan are low or poor in energy resources. These 13 provinces have a combined energy reserve of only 13 percent of the national total, but they have 63 percent of China's total population and consume 65 percent of the total energy.

An analysis based on the per capita energy alone has its shortcomings. Due to the great differences in population among the provinces and regions, places very low population such as Qinghai and Xizang appear to be particularly rich in energy, whereas heavily populated provinces such as Shandong and Henan become deemphasized in their energy resources. We should therefore consider other methods of resource assessment.

The energy density is the amount of energy resources divided by the area of the land. The national average energy density is 70,000 tons of standard coal per square kilometer. If we consider provinces and regions with an energy density greater than 1.5 times the national average as energy rich regions, then Shanxi, Ningxia, Nei Monggol, Guizhou, Anhui and Yunnan belong to this category. Areas with medium energy reserves (0.7-1.5 times the national average) include Shaanxi, Sichuan, Henan, Shandong, Hebei and Xizang. These are mostly energy exporting regions. Areas with a low energy reserve (less than 0.3 of the national average) include those well-known energy poor provinces and regions as well as Heilongjiang Province and Xinjiang Autonomous Region. The last two places are included in the category of low energy reserve and energy-poor regions because they have vast areas of land and hence a low energy-to-land ratio. This method of division evidently does not reflect the actual situation.

Since the energy resources in the provinces and regions have all been developed to some extent (Xizang is an exception) and only hydropower is lagging behind, the degree of ensurement of energy production and supply has a special meaning as an indicator. The amount of energy resources per 100 million yuan of industrial production has a national average value of 12.77 tons of standard coal. Seven provinces and regions--Shanxi, Ningxia, Heilongjiang, Xinjiang, Nei Monggol, Guizhou, and Henan--have a value greater than 1.5 times of the national average. Shandong, Jiangxi, Sichuan, Yunnan, Anhui, Gansu, and Qinghai are higher than the national average and less than 1.5 times the national average, they are the medium energy regions. Regions with a low energy reserve (0.7 to 1.0 times the national average) include Jilin, Shaanxi, Hebei and Henan. Energy-poor provinces and regions (less than 0.7 times the national average) include Liaoning, Guangxi, Fujian, Guangdong, Hubei, Jiangsu, and Zhejiang. In this division, Gansu, and

Qinghai are hydropower exporters and coal importers, Shaanxi has an excess of coal but lacks hydropower and oil, Jiangxi lacks coal but is more developed and hence in the first category. The division in terms of industrial value of production is somewhat different from the other methods of assessment.

Table 2 shows the classification of the provinces and regions in terms of their energy reserve as a fraction of the national total, and the abundance, density and the degree of ensurance in energy production and supply. This table allows specific comparisons to be made.

In an overall view, China's coal distribution is mainly in Shanxi and the adjacent Hebei, Nei Monggol, Shaanxi, Ningxia, Anhui and Shandong; oil distribution is in Heilongjiang, Hebei and Shandong, and hydropower distribution is in Gansu, Qinghai and Ningxia on the upper reaches of the Huang He, in Sichuan on the Dadu He and the Yalong Jiang, in Guangxi on the Hongshui He and in Guizhou on the Wu Jiang. These are not only China's important energy bases, they also have sound conditions for development.

But a closer look shows the resource distributions within each large region to be very nonuniform. Heilongjiang Province in the northeastern region, Anhui Province and Shandong Province in the eastern region and Henan and Guangxi Provinces in the central south region are relatively rich in energy resources. On the other hand, Hebei Province in the northern region, Gansu Province in the northwest, and Sichuan Province in the southwest are relatively poor in energy resources. On the provincial level all the provinces in the northwest may qualify as energy-rich regions or regions of medium energy resources. But regions such as Hanzhong, northern Shaanxi, Longdong, the Hexi corridor, the mountainous area in southern Ningxia, and the plateau in southern Qinghai are quite poor in energy resources.

In the energy-economic regionalization we should first consider the basic situations and characteristics described above.

## II. Classification System of Energy-Economic Regionalization and Proposed Criteria for First-Order Regions

Up until now, China has not had a well-defined or comprehensive economic regionalization scheme. The six large regions formed historically are only collections of provinces and regions of an economic cooperation nature. Furthermore, the geographic distribution and flow of the energy resources are constrained by the natural environment and the transportation network and cannot completely coincide with an administrative demarcation. Therefore, in the energy-economic regionalization we should on the one hand take into account the status quo and on the other hand break away from the constraints of the administrative demarcation.

In China it is necessary to divide the energy-economic regions into two orders. This is because the natural and economic conditions vary greatly from region to region and the distribution of energy resources is very unbalanced. The developmental process of China's economic system also dictates such a division.

A first-order energy-economic region is a large region of comprehensive energy development, production and marketing. A first-order region is formed on the

Table 2 The degree of ensurement of energy resources in China

Province or region	percentage of national total	per capita energy resource (ton, std. coal)	per unit area energy resource (10 <sup>4</sup> ton/sq km)	per unit of industrial value (10 <sup>4</sup> ton/10 <sup>8</sup> yuan)	Energy abundance	energy density	degree of ensurement
Hebei	2.1	213	6.9	11.3	3	2	3
Shanxi	21.3	5857	92.9	78.6	1	1	1
Nei Monggol	20.5	7429	11.6	28.7	1	1	1
Liaoning	1.0	195	4.8	8.1	3	3	4
Jilin	0.7	230	2.8	12.6	3	3	3
Heilongjiang	2.1	443	3.0	48.7	2	3	1
Jiangsu	0.5	49	3.2	1.1	4	3	4
Zhejiang	0.3	51	1.9	1.1	4	4	4
Anhui	2.5	350	13.1	14.4	2	1	2
Fujian	0.6	150	3.1	6.5	3	3	4
Jiangxi	0.4	89	1.8	15.2	4	4	2
Shandong	1.7	160	7.7	18.1	3	2	2
Henan	2.1	193	8.4	24.5	3	2	1
Hubei	0.9	129	3.3	2.9	3	3	4
Hunan	1.0	130	3.2	11.6	3	3	3
Guangdong	0.6	73	2.0	3.4	4	4	4
Guangxi	1.0	192	2.9	2.0	3	3	4
Sichuan	7.5	521	9.1	14.7	2	2	2
Guizhou	5.7	1396	22.8	24.2	1	1	1
Yunnan	6.3	1350	10.9	14.5	1	1	2
Xizang	9.0	33202	5.1	—	1	2	—
Shaanxi	2.8	675	9.5	12.4	2	2	3
Gansu	1.3	479	2.0	13.4	2	4	2
Qinghai	1.4	2612	1.3	12.9	1	3	2
Ningxia	3.2	5764	35.9	63.7	1	1	1
Xinjiang	3.3	1776	1.4	41.3	1	4	1

Note Beijing and Tianjin are combined with Hebei and Shanghai is combined with Jiangsu. All based on 1980 figures. Classifications-- 1-rich, 2-medium, 3-low, 4-poor, classification criteria are stated in the text.

basis of the completeness of the resources in the region and the balance of energy supply and demand in the national economic development. The first-order regionalization will ensure the gradual formation of large region industrial systems in China and play a role in the overall layout and planning of China's energy industry. A first-order region should satisfy the following criteria: (1) It should have abundant energy resources and a strong network of energy bases; (2) It should have a large energy consumption and a number of relatively concentrated energy consumption points; (3) The energy demands in the region can preferably be satisfied by the energy production bases in the region and a balance in supply and demand can be achieved so that the energy development in the region is compatible with the overall economic structure; and (4) It should have adequate transportation and a relatively complete energy transportation network to meet the needs of the energy bases and the supply and demand in the region.

The second-order energy-economic regions are typical energy regions based on the richness of resources in the region and the unique features of the energy-economic structure. A second-order region should be distinctly different from other regions in terms of the emphasis of the energy structure, and the relationship between the economic structure and the energy consumption. The second-order regions should serve as a basis for the formation of specialized industrial complexes and provide a direction for the regional industrial development and the construction of local energy bases.

The energy development should serve the consumption of energy and must be based on the availability of the energy resources. In reality, however, the geographic distributions of resources and consumption are often incompatible. Therefore, the primary task of the energy-economic regionalization and the main purpose of first-order energy-economic region demarcation are the scientific combination and rational determination of the production and consumption relationship between energy resources and energy consuming regions in order to provide each region (especially the large economic regions) with a fuel power base and to aid the formulation of energy policies regarding the comprehensive development and utilization of energy.

We now describe the procedure and method in the demarcation of first-order energy-economic regions:

(1) First conduct economic appraisal of the resources and identify the regions qualified for the establishment of energy bases. An inter-regionally significant energy base available for construction should not only have considerable high quality resources and sound development conditions, but also convenient transportation, close proximity to major energy consumption centers or areas, and be surrounded by regions of considerable economic development. In the authors' opinion, a first-order coal base should have at least 3 billion tons of verified reserves and the final output should be 15 million tons per year or greater. For an oil base the verified reserve should be 1 billion tons or more and the annual production should reach at least 10 million tons. Hydroelectric power stations (a group of hydropower stations) should be 5 million kilowatts or greater and the annual output should be 20 billion kilowatt-hours or more. Based on these criteria, the available energy bases in China are listed in Table 3 together with their magnitude appraisal.

Table 3 Main energy bases with inter-regional significance available for construction in China

Type of energy	Name of base	Location (province)	Scope	Size	Ultimate output (10 <sup>4</sup> tons)
Coal	1. Eastern Hebei	Hebei, Tianjin	Kailuan, Jiayu	Large	2,500
	2. Southern Hebei and northern Henan	Hebei, Henan	Fengfeng, Handan, Hebi	Large	2,000
	3. Northern Shanxi and southern Nei Monggol	Shanxi, Nei Monggol	Datong, Pingshuo, Jungar	Extra large	15,000
	4. Central Shanxi	Shanxi	Yangquan, Xishan, Gujiao, Fenxi, and Huo Xian	Very large	10,000
	5. Southeast Shanxi and northwest Henan	Shanxi, Henan	Jincheng, Luan and Jiaozuo	Very large	5,000
	6. Liaoning	Liaoning	Fushun, Fuxin, Hongyang, and Tiefa	Large	3,000
	7. Eastern Heilongjiang	Heilongjiang	Jixi, Hoga, Shuangyashan and Zitaihe	Large	4,000
	8. Yiminhe	Nei Monggol	Yiminhe (brown coal)	Large	2,000
	9. Huolinhe	Nei Monggol	Huolinhe (brown coal)	Large	2,000
	10. Southern Shandong	Shandong	Zaozhuang, Tengnan, Jining and Yanzhou	Large	3,000
	11. Anhui and Jiangsu	Anhui, Jiangsu	Huaibei, Xuzhou, and Fengpei	Very large	3,500
	12. Southern Anhui	Anhui	Huainan	Very large	3,500

Table 3 continued

Type of energy	Name of base	Location (province)	Scope	Size	Ultimate output (10 <sup>4</sup> tons)
Coal	13. Western Henan	Henan	Pingdingshan, Yuxian, Xinmi, and Yima	Very large	3,500
	14. Western Guizhou	Guizhou	Panxian, Shuicheng, Liuzhi, and Zhina	Very large	3,000
	15. Northern Shanxi	Shanxi	Tongchuan, Hancheng, Chenghe, and Pubai	Large	2,500
	16. Helanshan, Zhuozishan	Ningxia, Nei Monggol	Zhuozishan, Wuda, Shitanjing, Shizuishan, and Hulusitai	Large	2,000
Oil	17. Northern China	Tianjin, Hebei	Jizhong, Dagang	Large	1,500
	18. Daqing	Heilongjiang, Jilin	Daqing, Fuyu	Very large	5,000
	19. Shengli	Shangdong, Henan	Shengli, Dongpu	Large	1,800
Hydropower	20. Southern system	Guizhou, Guangxi	10-cascade power stations from Tianshengqiao to Datengxia		11 million kilowatts
	21. Southwest system	Sichuan, Yunnan, Guizhou	Gongzui, Tongjiezi, Ertan, Tongzilin, Lubuge, Manwan, Wujiangdu, and Pengshui		8 million kilowatts
	22. Central system	Hubei, Hunan	Danjiangkou, Gezhouba, Geheyan, Sanxia Low Dam, Touxii, Fengtan, Dongjiang, Wuqiangxi		20 million kilowatts
	23. Northwest system	Qinghai, Gansu, Ningxia	16-cascade power station from Longyangxia to Qingtongxia		12.6 million kilowatts

(2) Rationally designate marketing zones for the energy bases and seek the economically optimum relationship between energy bases and major consumption regions

To find the best production and marketing relation for the energy regions, we must rationally designated supply zones for the major coal bases. The current method used in the demarcation is primarily based on the principle of the least social labor expense (the entire social labor including production and transportation). The specific measures are: 1) Calculate the standard coal production and transportation costs according to the production costs and heat contents of the raw coal at the various coal bases; 2) Determine the transportation cost of coal on the various transportation lines in the different regions; 3) Using the above data find the location on the transportation lines connecting two adjacent coal bases where the sum of the production cost and transportation cost is the same for both ways. This point will be the dividing point for the coal sales of the two bases; 4) Finally, by connecting these points we have a rational designation of the marketing regions for the coal bases in China. (See Fig 1)

After more than three decades of construction in the area of electric power production, China now has 12 thermoelectric power grids, each producing 1 million kilowatts or more, and five interprovincial power grids. China has 100,000 kilometers of transmission lines with a voltage higher than 110 volts. Based on the distribution of sources and loads, seven regional power grids will be formed in the near future. They are the northeast, north, east, central, southwest, northwest and Guangdong and Guangxi. The distribution of existing and future hydro-power and thermoelectric power plants in the power grids and the volume and direction of electric current flow are also important inputs to the energy-economic regionalization.

(3) Form large-scale comprehensive marketing regions by combining the marketing regions of the energy bases

Since the resource condition, development scale and consumption in the marketing regions of the various coal bases are different and the resource structure and consumption structure of the various regions are not the same, there exists considerable difference in terms of surplus and deficit among the regions and among the various types of energy. In order to have them complementing each other and to achieve sufficient and rational development of each region and each energy resource and to ensure the overall balance between supply and demand, we must consider the geographic distribution and the unique features of the resources and appropriately combine the marketing regions of the energy bases to form a number of energy base series with sufficient resources and adequate complementation among them. These large energy base regions must have enough consumption and a certain number of relatively concentrated consumption centers. The supply and demand should be basically in balance in such comprehensive energy development and marketing regions.

(4) Finally, the first-order energy-economic regions may be designated after taking into consideration future development in transportation, the trend of large regional industrial systems and the demarcation of the administration divisions. The proposal is as follows: (see Fig 2)

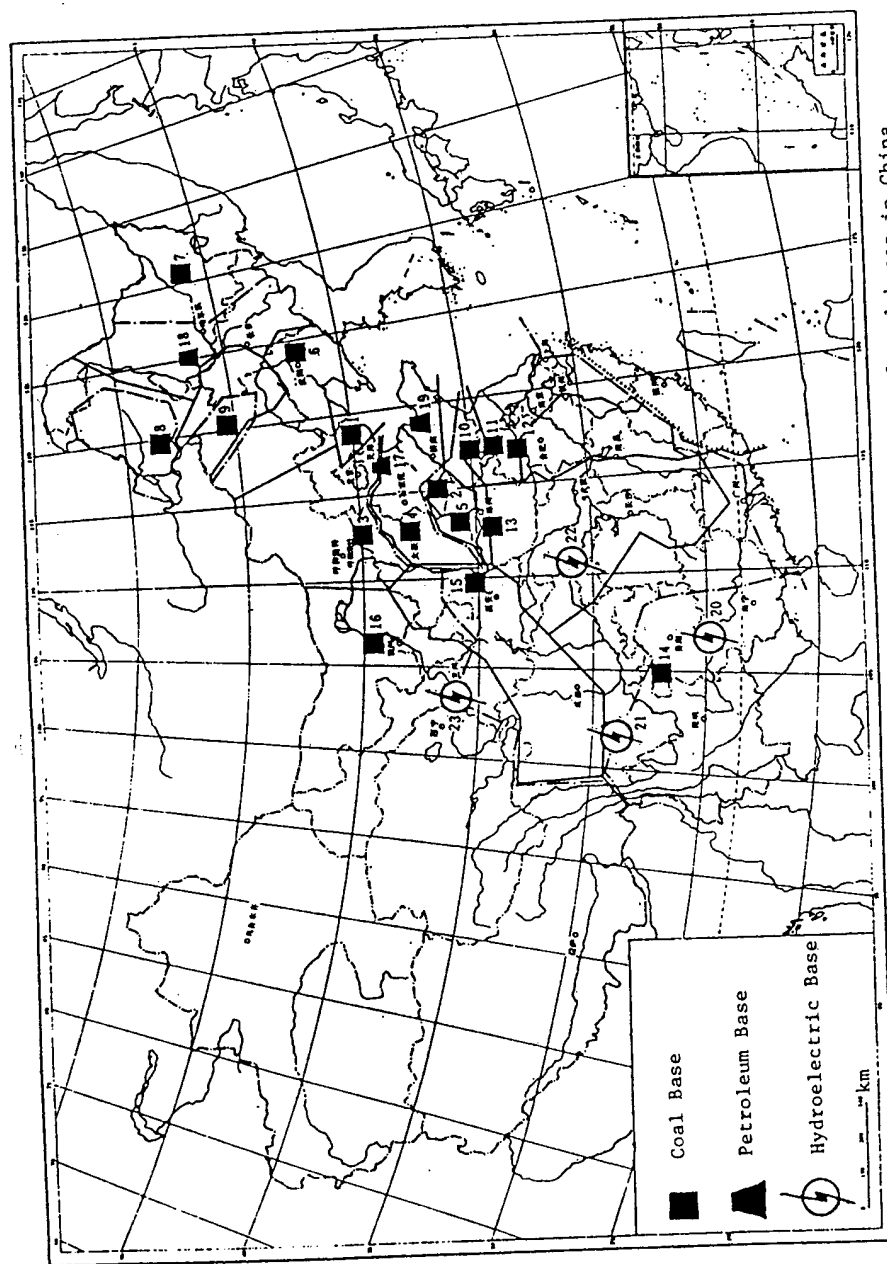


Fig 1 Distribution of main energy bases and marketing regions of coal bases in China

—— Rational boundary of Coal Base Supply.

- - - Rational boundary of supply of large coal bases in northern, central and southeastern Shanxi.

..... Rational boundary of supply by sea of Shandong coal.

1. Eastern Hebei, 2. Southern Hebei and northern Henan, 3. Northern Shanxi and southern Nei Monggol, 4. Central Shanxi, 5. Southwestern Shanxi and northwestern Henan, 6. Liaoning, 7. Eastern Heilongjiang, 8. Yiminhe, 9. Huolinhe, 10. Southern Shandong, 11. Anhui and Jiangsu, 12. Southern Anhui, 13. Western Henan, 14. Western Guizhou, 15. Northern Shanxi, 16. Helanshan and Zhuozishan, 17. Northern China, 18. Daqing, 19. Shengli, 20. Southern system, 21. Southwest system, 22. Central system, 23. Northwest system



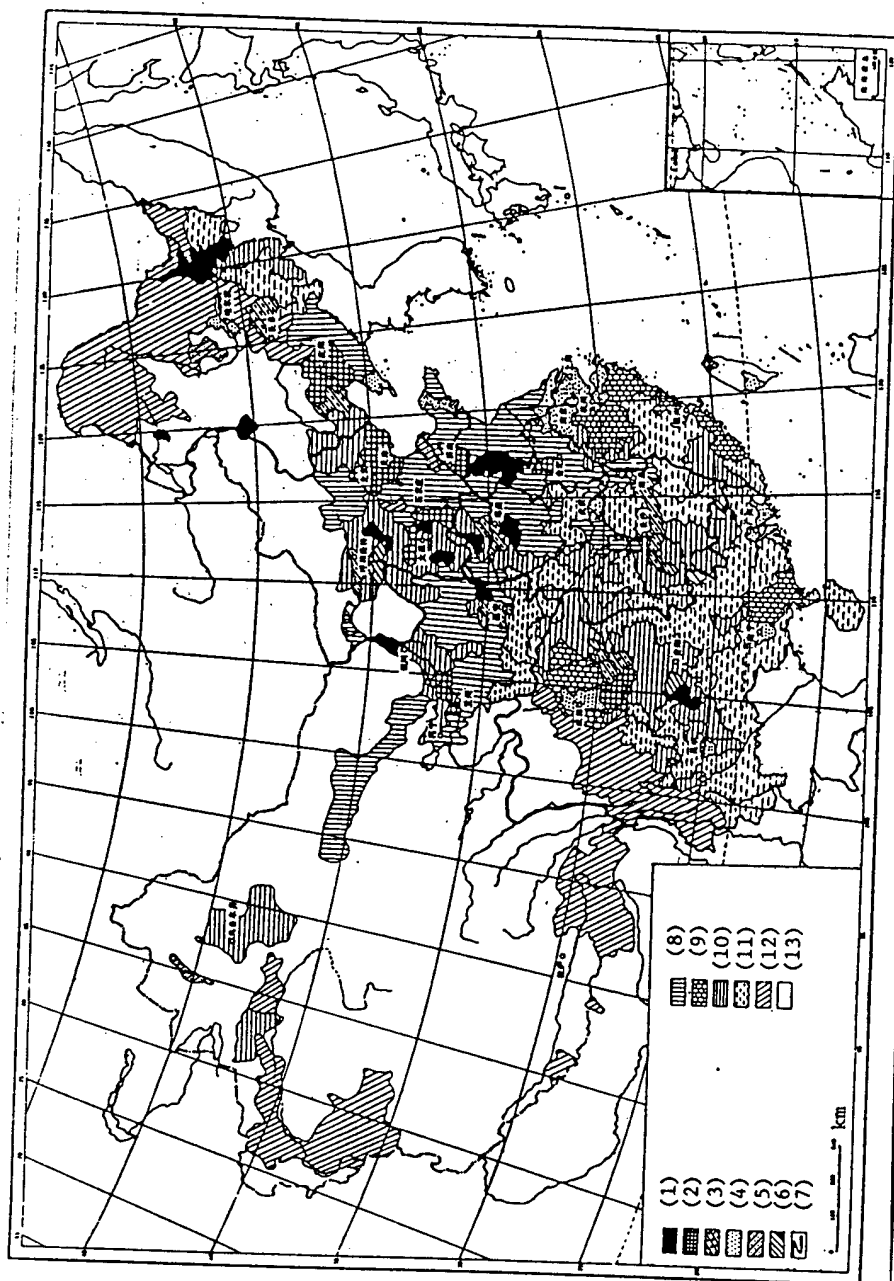


Fig 2 Proposed energy-economic regionalization of China

Key: 1) Coal development and export; 2) Energy-industry integrated development; 3) Processing industry and energy production; 4) Highly developed industrial zone far from energy sources; 5) Oil development; 6) Long-term energy development; 7) First-order energy-economic regions; 8) Methane; 9) Methane and small-scale hydropower; 10) Local coal; 11) Small-scale hydropower; 12) Firewood; 13) Livestock breeding.

1. Northeastern region: Liaoning, Jilin, Heilongjiang and eastern Nei Monggol.
2. Northern region: Beijing, Tianjin, Hebei, most of Shanxi, central Nei Monggol and north central Shandong.
3. Eastern region: Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Taiwan, southern Shandong (Heze, Jining and Linyi Prefectures and Zaozhuang city), Northeastern Jiangxi (Jingdezhen and Shangrao Prefectures), eastern Guangdong (Shantou and Meixian Prefecture) and Yongcheng and Xiayi counties in Henan.
4. Central region: Henan (except Yongcheng and Xiayi counties), Hubei, Hunan, most of Jiangxi, southern Shanxi (Yuncheng Prefecture and the counties and cities of Xiangning, Quwo, Houma, Yicheng, Jincheng, Yangcheng, Gaoping, Lingchuan and Qinshui).
5. Southern region: Most of Guangdong, Guangxi, Sichuan, Guizhou and Yunnan.
6. Western region: Shaanxi, Gansu, Ningxia, Qinghai, western Nei Monggol, Xinjiang and Xizang.

The lower half of Table 1 shows the basic energy resources data of the first-order energy-economic regions. In this division, the northeastern region becomes a complete regional unit and the energy-economic region coincides with the comprehensive economic region. With eastern Nei Monggol included in the northeastern region, the abundance of coal is highly improved and the construction of coal bases in eastern Nei Monggol should henceforth be conducted with the overall situation of the northeastern region taken into account. The central northern part of Shandong is included in the northern region. This designation is not only consistent with the regionalization of the oil field geological system--Jizhong, Huanghua and Linqing depressions and the Bo Hai belong to the north China sedimentary basin--and favors the unified management and development of the oil fields but also agrees with the rational marketing region of coal. Northern Shandong is short of coal and should be supplied by Shanxi, the coal produced in southern Shandong should be transported to the south and not to Jiaodong in the north. The energy resources in Jiangxi Province will be basically self-sufficient in the near future except that the northeastern region should be supplied with Huainan coal. Any shortfall in the future should be made up by coal from the north transported into Jiangxi along the Nanjing-Guangzhou Railroad and by electric power from Gezhouba. Hence, with central northern Shandong and most of Jiangxi taken out of the eastern region and with Guangdong and part of Henan included in the eastern region, the resources of the eastern energy-economic region is somewhat more than that of the eastern economic cooperative region and the supply of energy is more concentrated. Historically, the three provinces of Hubei, Hunan and Jiangxi are the main body of the central China economic region. In the last few decades these three provinces and Hunan are even more closely related as a result of the supply of coal from Henan to Hunan and Hubei and the combination of thermoelectric power from the north and hydroelectric power from the south in the central China power system. In addition the proposal also includes the southern part of Shanxi into the central region to further establish the transport of anthracite to the south (the export of southern Shanxi anthracite at the present time is also mostly to the central-south region) and the flow of the Xiangning coke mining area to be developed, so that the central region can become a complete energy-economic region. Guangdong and Guangxi Provinces are an important energy shortage area in China, except for the rich hydropower in Guangxi, and

most of the fuel required by the two provinces is brought in from faraway sources. By combining the three provinces in the southwest with Guangdong and Guangxi, the abundant coal in western Guizhou and southern Yunnan will amply supply the needs in Sichuan, Guangdong and Guangxi. It also favors the unified planning of large hydropower developments on the Hongshui He and the Nanpan Jiang to supply the Guangdong/Guangxi area and the matching of thermoelectric and hydroelectric power and the transportation of fuel. Even though at the present time transportation conditions limit the supply of Liupanshui coal to Guangdong and it costs less to import coal from the north, from a developmental point of view the new scheme has greater advantages. As for the region, because of the vast area and the low economic development, it will have to remain a loosely organized energy-economic region for a certain period of time except the closer supply and demand relation among the three adjacent provinces of Gansu, Ningxia and Qinghai.

### III. Appraisal of First-Order Energy-Economic Regions

#### (1) The Northern Region

The northern region is the region with the highest degree of ensurement in energy resources and is an advanced industrial area as well. The industrial value of production of the northern region is more than one-fifth of the national total. Here we have one-half of China's confirmed coal reserve and one-third of the verified oil reserves and this region produces more than one-third of China's coal and oil output today. Most of the coal fields in this region have concentrated deposits and thick, stable seams. They are superior for development and produce the best economic results. Furthermore, the northern region is centrally located and can supply coal to the whole country. Today there are eight large and very large coal mines in the region which supply 60 million tons of coal a year to the east, central south and northeast. This region has three oil fields and produces 30 million tons of crude oil a year. The crude oil can be conveniently processed in the region or exported to other places. The main body of the northern power grid based on the rich coal resources has been established but the hydropower reserves are rather limited.

Based on the availability of resources in the northern region, the main emphasis for the future should be the construction of the coal bases. Existing oil fields should continue their production and the prospecting of offshore oil fields in the Bo Hai should continue. The major coal bases should include Datong and Shuo Xian in northern Shanxi, Xishan, Yangquan and Fenxi in central Shanxi, and a suitable expansion of Kailuan (in eastern Hebei), Fengfeng and Handan (in southern Hebei), and Helan-Zhuozishan (in Wuhai City), and the long-term candidate, Jungar. These coal bases are capable of producing 300-400 million tons per year within 20 years and can supply both the north and the south and provide coal for export as well.

The increasingly large scale of development may bring the following major problems: 1) It puts great pressure on the transportation system. In particular, railroad trunk lines leading into and out of Shanxi and heading for northeastern China, eastern and central southern China and the major seaports in northern China will bear a heavy load in coal transportation; and 2) The construction of energy (especially the Shanxi coal base) must be matched by growth in agriculture, light industry and other capital construction. But the present economic structure is too weak to support the development of energy bases.

In the future effort to develop the energy resources in the northern region, transportation should be greatly reinforced. In addition to improving existing railroads, new lines linking the major coal fields in Shanxi directly to the seaports should be built as early as possible to ensure the unimpeded export of large amounts of coal. In the meantime, thermopower bases and fuel processing plants should be laid out rationally to diversify the export of energy. The supply of coal and electric power to energy-deficient areas in the region should also be improved. We should gradually and systematically build those energy bases having the proper conditions into integrated industrial bases. Blessed with rich iron ore, nonmetallic minerals, and ocean salt and complementary sources of fuel, the northern region should become China's major development area of steel, chemicals, building materials and other energy-consuming industries. Since this region is relatively weak in water resources, the main goal of the power industry should be self-sufficiency. An appropriate amount of electric power may also be exported to the northeastern region by connecting the two power grids.

Large energy consuming industries should not be developed in Beijing and Tianjin where the consumption of energy is already too concentrated.

## (2) The Northeastern Region

The northeastern region is well-developed and has a variety of energy resources, a high level of energy consumption and a high concentration of industries--especially heavy industries. It has 50 percent of the confirmed oil reserve in China, 9.1 percent of China's coal and some oil shale and hydropower resources. Its current annual output of oil is 50 million tons and the output of coal is about 100 million tons. In terms of the production structure, it is the only major region in China where the percentage of oil (52 percent, or 56 percent including natural gas) is higher than the percentage of liquid fuel (36 percent) in its energy consumption structure. More than one half of Daqing's crude oil output are exported to other parts of the country. Since the northeastern region also has one-third of China's petroleum processing capacity, more than one-half of the petroleum products are also transported out of this region. Even though it has a large output of coal, it still must import great amounts of raw coal--almost 20 million tons per year and rising--because of its high level of energy consumption. Liaoning Province has a shortage of all types of fuel and power.

The energy potential in the three northeastern provinces is no longer great. The only available coal reserves are in the eastern part of Heilongjiang and some isolated medium-scale coal mines in central Liaoning. Old mines such as Fushun and Benxi have entered the depletion stage. The development of the Daqing oil field has peaked and will be entering a declining stage. As for hydropower, most of the border rivers do not have development potential and there is only a limited number of dam sites inland. But since coal-rich eastern Nei Monggol is now included in the northeastern energy-economic region, the resource abundance is increased considerably. The per capita energy reserve within the three provinces from 293 tons of standard coal to 554 tons of standard coal.

Since the main transportation link through Shanhaiguan is the Beijing-Shenyang Railroad and no new trunk lines will be built in the near future, the amount of coal that can be hauled out of Shanhaiguan is limited. On the other hand, transmitting electric power from the northern region over this long distance is more costly than hauling coal. Therefore, our main strategies for achieving a balanced energy supply and demand in the northeastern region should include the following: 1) Suitably expand the coal base in eastern Heilongjiang; 2) Speed up the construction of medium coal mines in Tiefa and Hongyang in Liaoning in order to compensate for the declining output of the old mines and prevent the Liaoning coal output from dropping; 3) Even though the three large open-pit mines in eastern Nei Monggol produce brown coal and are located too far to the west, since the reserve is great and special railroads are already built, they should be developed as soon as possible and thermopower plants should be built to supply Liaoning with electricity; 4) Since this region (especially Liaoning Province) has a high capacity for crude oil processing and has a concentration of heavy industry, some of the crude oil may be allocated for industrial use; 5) Build nuclear power plants in the coastal area of Liaoning; and 6) Control the development of energy-intensive industries in the region, especially in Liaoning, keeping the level of energy consumption basically at the present level.

### (3) The Eastern Region

The eastern region has the highest population density and the highest level of economic development. It has approximately 23 percent of China's population and about 30 percent of the nation's total industrial value of production. This is especially true for the triangle area in the lower reaches of the Chang Jiang where the industrial value of production of the major industrial centers along amounts to one-fifth of the national total. But the eastern region is very poor in energy resources, the abundance is only about one-fifth and one-seventh respectively of the national average according to population and industrial value of production. The main energy source is coal in Anhui and Jiangsu and there are a few hydropower resources in Fujian and Zhejiang. But since the resources are concentrated, the transportation is convenient and the surrounding areas have reasonable agricultured and industrial development, most of the reserves can be developed into medium or large energy producing regions. The disadvantages are that the coal fields are deeply buried, often under complex geological structure, which to a certain extent increases the investment and production costs and the flood losses of the hydropower dam sites are relatively large.

The eastern region has large coal bases including Huainan, Huaibei, Xupei and Lunan and medium hydropower stations such as the Xinanjiang station. In 1980 the energy output of the eastern region was equal to 9 percent of the national total but the energy consumption in the same year was 22 percent of the national total. The annual energy import of this region has reached 37 million tons of standard coal, out of which two-fifths are coal and three-fifths are oil. Along with the rapid development of industry and agriculture in this region, the level of energy consumption and the amount of fuel brought in are expected to increase considerably. Anticipating this increase, we should take the following measures: 1) Complete the Lunan, Huainan and Huaibei coal bases as quickly as possible; 2) Except on specific coal bases, large energy-intensive industries should not be developed. Since the eastern region has a large population with a high tech-

nical level, the direction of future industrial development should more toward high precision products and labor and technology intensive products and export processing; 3) Make early plans for the construction of transportation lines, stations and harbors; 4) Expand the Huaibei, Huainan, Xuzhou and Lunan thermopower stations and develop hydropower in Zhejiang and Fujian, making them part of the eastern power grid; and 5) In terms of a national balance in energy production and marketing, the energy shortage in the eastern region will mostly be made up by coal from the northern region and hydropower from the central region. But in view of the acute energy shortage in the delta area of the lower Chang Jiang, immediate efforts should be made to prospect promising oil and gas resources in the East China Sea and to build nuclear power plants.

#### (4) The Central Region

The central region is also a region with the highest population density in China, an established industrial and agricultural base and insufficient energy resources. The per capita energy reserve of the central region is higher only than that of the eastern region.

The central region has one-tenth of China's coal reserves, most of it in Henan and southeastern Shanxi, the hydropower reserve is large, mainly on the tributaries and branches in the middle reaches of the Chang Jiang. With coal in the north and hydropower in the south, the central region has well-balanced resources.

Coal is fairly developed in the central region, the annual output being about 100 million tons. Henan and southeastern Shanxi provide great amounts of coal, Hubei takes in large quantities of coal, and Hunan and Jiangxi are not quite self-sufficient in coal. Today 14 million tons of coal come from Henan every year, just enough to make up for the shortfall in Hubei, Hunan and Jiangxi. In terms of variety the central region lacks the rich coal and coke resources and relies on the northern and eastern regions for supply. With the southern part of Shanxi included in the central region, the variety and quantity of coal will be better in the future.

The central region is the hub of China's communications network. It has a good industrial and agricultural base, an ample labor force, superior conditions for industrial development and its energy needs will be increasing with time. Hunan and Jiangxi have limited amounts of coal and the present preproduction level is becoming difficult to maintain, whereas western Henan and southern Shanxi have concentrated reserves of high quality coal near trunk railroad lines; priority anthracite coal bases in southern Shanxi and western Henan should build in the near future. In the meantime, coke fields may be build in Xiangning in southern Shanxi. Since the hydropower resources in this region are close to electric power load centers, they should be developed in the near future even though the flood loss of individual dam sites is relatively large. In addition to the Danjiangkou station already built and the Gezhouba station under construction, work should begin to develop hydropower in Hunan and Sanxia so that the Hunan-Hubei power grid, principally based on hydropower, can connect with the Henan thermoelectric power grid and the Sichuan power grid to form a large electric system and supply the eastern region with large quantities of electric power.

#### (5) The Southern Region

The southern region has one-fourth of China's population, one-seventh of the national industrial value of production and one-fifth of China's resources. Since there exists pronounced differences in the geographic distribution of the resources (mainly concentrated in the central area) and the distribution of population and industry (mainly on the Zhujiang Delta and in the Sichuan Basin), the abundance of resources varies considerably in this region. For example, the resources of Guizhou are 17 times those of Guangdong. The major resources in this region are hydropower and coal. The coal resources are next only to the northern region and the northwestern region and the hydropower resources are the highest among all the regions. The energy structure in this region is characterized by the high percentage (63.4 percent) of hydropower. This is favorable to the development of the rich nonferrous mines in the region. But most of the energy resources are in the mountainous area surrounded by areas of low economic development, have poor transportation conditions and are far from economic centers. As a result, the development investments and transportation costs are often high, and the transportation is often hampered by the natural environment.

Today some energy bases have been established in the southern region, such as the coal base at Liupanshui, hydropower in western Sichuan and natural gas in central Sichuan. The 1980 energy output of the region was 11 percent of the national total, but compared to the 21 percent of the total energy resources in China, there is still great potential for development. In 1980, 13 million tons of standard coal were transported into the southern region, mostly petroleum and petroleum products. Even though the energy needs of this region will increase considerably in the future, there does not appear to be great problems in balancing the supply and demand in this region. Since the resource distribution in this region is extremely unbalanced, dam sites on the Hongshui He, Yalong Jiang and Wu Jiang with good economic conditions and close to consumption centers and the coal fields in Liupanshui should be developed quickly and a major effort should be made to develop the transportation system. Some nuclear power may be developed in Guangdong and future developments of the petroleum resources in the South China Sea will greatly improve the energy structure of the southern region.

#### (6) The Western Region

The western region has the greatest area and the least population and is an energy-economic region with a complete variety of energy resources and rich reserves. It has 12 percent of China's coal reserves next only to the northern region, 14 percent of the original oil reserve and 41.6 percent of China's hydropower reserves. The five northwestern provinces have 12.5 percent of the nation's hydropower reserves. The per capita energy reserve is the highest of all the regions.

The present outputs of coal, oil and hydropower in the western region are not large, but due to the low level of industrial and agricultural development, production exceeds demand. Besides self sufficient in fuel, Shaanxi and Ningxia have exported 7 million tons of coal in 1980, almost one-fifth of the national coal production. Gansu, Qinghai and Xinjiang also have some extra oil for export.

The western region is sparsely populated, the economically developed areas are mainly in Guanzhong, Longzhong, the Hexi Corridor and the oases on the slopes of Tian Shan in Xinjiang. The fuel resources are mainly distributed on the east and west ends. Coal deposits are in Shaanxi's Weibei, Ningxia's Helan Shan and the northern slope of Tian Shan in Xinjiang; oil fields are in the Qaidam, Junggar and Tarim basins, hydropower resources are mainly concentrated on the upper Huang He and Xizang has 30 percent of china's hydropower resources. Most of these places have a sparse population, harsh natural environment and are far from the large energy consuming areas in the country and at considerable distances from the economic centers in the region. Energy must be transported over large distances but the intrinsic conditions of the energy resources favor development.

Inter-regionally significant energy bases are the hydropower bases on the upper course of the Huang He in Qinghai, Gansu and Ningxia, the Weibei Coal base in Shaanxi and Helan Shan Coal base in Ningxia, and the oil bases in Xizang. With the accelerated development of the upper reaches of Huang He, the expansion of the coal bases in Shaanxi and Ningxia and the completion of the power transmission network, the matching of thermopower and hydropower will be improved, more coal will be developed and an important energy base will be formed to support the neighboring regions and to develop energy-intensive industries. Xinjiang is the most promising land-based petroleum resource area in China, new oil fields have been discovered and development may begin as soon as the amount of reserve is confirmed, but the investment will be very large. As for the rich hydropower in Xizang, development will have to wait till the distant future because of the remoteness of the locations.

#### IV. Demarcation of Second-Order Energy-Economic Regions

Within the first-order regions, we may further divide into urban regions and rural regions based on the distribution, structure and abundance of the energy resources, types of existing energy bases and the layout of their associated facilities, level and structure of economic development and the degree of self-sufficiency of the conventional energy resources.

The urban area may be divided into: (1) coal development and export zone, (2) oil development and export zone, (3) energy and industry integrated development zone, (4) processing industry and energy production zone, (5) concentrated industrial development zone with concentrated consumption and far away from energy resources, (6) long-term energy development zone, and (7) scattered small and medium cities.

The rural area can be divided into: (1) firewood fuel zone, (2) livestock zone using animal manure and hay, (3) northern agricultural zone using stalks and firewood supplemented by coal, (4) southern agricultural zone using methane, supplemented by small hydropower and firewood, (5) small hydropower zone, supplemented by other types of fuel, and (6) local coal zone. Figure 2 shows the distribution of the various types of areas.

The final goal of the second-order energy-economic regionalization is to consider the resource conditions, economic development level and supply and demand characteristics of the different types of areas, formulate the corresponding



energy plan, policy and measure so that unique energy bases may be systematically built and the increasing energy needs in the cities and on the countryside may be satisfied in a variety of ways.

We recommend that the responsible department formulate energy policies designed to suit the situation of the various energy-economic regions. In the integrated balance of economic planning, the marketing region and flow direction of each energy resource (mainly coal) may be devised according to statistical analysis of the energy-economic regions and tried out first. When the conditions become compatible, the energy-economic regionalization system may be made consistent with the energy production and management system.

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## POWER NETWORK

### LINKING GRIDS WILL RELEASE SURPLUS ELECTRICITY FROM THE NORTHWEST

HK180222 Beijing CHINA DAILY in English 18 Mar 84 p 4

[Report on LIAOWANG article: "Power Grid Needed for Electricity 'Sharing'"]

[Text] While much of China suffers from a power shortage, the northwestern provinces have more than they can use at their present stage of development. The Electric Power Industry Administration of Northwestern China has mapped plans not only for sharing its excess, but for increasing output.

Over the past decades, China has built up a number of separate power grids, but under the previous policy of expecting each area to be "self-reliant" they were never linked. Now that the policy has been changed to reduce administrative barriers of all kinds, the Northwestern Power Administration intends to try to help the whole country, as well as to develop the economy of its own area.

The immediate goal is to link up as soon as possible with neighboring power grids, so that some 2.2 billion kilowatt-hours (kWh) of electricity can be supplied annually to northern Sichuan, western Henan, and southern Shanxi provinces. When the national plan of linking all the grids is completed in 1986, power from the northwest will be available in such major industrial centers as Beijing, Wuhan, and Chongqing. During periods of abundant water supply, the northwest has a surplus generating capacity of around a million kilowatts (kW).

#### Inconvenience

By 1990, it is hoped to increase this surplus to 3 million kW; and by the turn of the century, to 10 million kW, out of a total generating capacity of 30 million kW. By then, the northwest will be supplying the rest of the country with 45 billion kWh of electricity per year.

One peculiarity of China's present limited generating capacity is that when the drain becomes dangerously high in peak-load periods, the only choice is to pull the switch. This not only inconveniences the people and shuts down factories, it means that power production itself halts. Having the back-up capacity of the northwest available will enable plants in north China to operate longer hours, adding some 3 billion kWh annually to their output.

The northwest itself is sometimes faced with this peak-load problem. Eventually, it is estimated that hydroelectric capacity in the northwest will expand annual output by 1.6 billion kWh. In terms of increased industrial production value in north and northwest China, this is expected to be worth 10 billion yuan (\$5 billion).

For the present, the most severe limitation on production of thermal power throughout the country is a shortage of coal. The northwest has plenty of coal but the rail lines are already clogged with shipments going east from the mines of Shanxi Province. Therefore, the Northwestern Electric Power Industry Administration has decided to ship out electricity rather than coal. It is estimated that exporting 10 billion kWh of electricity to Sichuan Province and central China each is equal to shipping 12 million tons of coal.

In addition to supplying power to other areas, the northwest believes it is an ideal site for relocating some power-hungry industries. So far, only 7.7 percent of its hydropower potential is being used, and less than 4 percent of its available coal.

Planned hydropower development centers on the Yellow, Han and Bailong rivers. On the Yellow, present plans call for 15 power stations extending from the Longyang Gorge in Qinghai Province to the Qingtong Gorge in the Ningxia Hui Autonomous Region with a total capacity of 13 million kW.

There area's coal is good, lying in [thick] beds close to the surface. The mining costs are less than the national average. It would not be difficult to mine an additional 12 million tons annually, enough to increase generating capacity by 4 million kW.

CSO: 4010/65

## POWER NETWORK

### BRIEFS

ZHEJIANG 220KV LINE--Hangzhou, 31 December (XINHUA)--A newly completed 220,000-volt power transmission line in Zhejiang Province was incorporated into the East China Power Grid today. The 188-kilometer Taizhou-Linhai-Wenzhou line is the 13th 220,000-volt transmission line in Zhejiang Province, officials here said. Seven of the lines were built after 1978. Construction of the new line, which crosses the Oujiang and two other rivers, involves the erection of 479 pylons. The East China Power Grid, which combines both thermal and hydroelectric power stations, supplies electricity to the country's biggest industrial city, Shanghai, and its surrounding cities and countryside. [Text] [Beijing XINHUA in English 31 Dec 83 OW]

NORTHEAST 500KV LINE --Shenyang, 28 January (XINHUA)--China's largest transformers went into trial operation yesterday on a 500,000-volt power transmission line between Nei Monggol and Liaoning Province. The eight 500,000-volt transformers were produced by the Shenyang transformer factory. The transmission line, one of China's key construction projects, uses all domestically-produced equipment and supplies electricity produced by thermopower plants in Nei Monggol and Liaoning to the industrial cities of Shenyang, Anshan, and Luda in northeast China. [Text] [OW281718 Beijing XINHUA in English 1622 GMT 28 Jan 84]

CSO: 4010/43

## HYDROPOWER

### 1983 IS RECORD YEAR FOR PRODUCTION OF HYDROELECTRICITY

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 1, 12 Jan 84 p 2

[Text] At the beginning of this new year, good news has been received from the hydropower front. In 1983, hydroelectricity generated throughout the country reached 83 billion kWh, i.e., 24 percent of the total electric power generated, an increase of 14 percent over last year's figure and 15 billion kWh more than predicted at the beginning of the year, setting an all-time record. The production of 83 billion kWh amounts to a saving for the state of over 33 million tons of standard coal.

Since 1980, the output of hydroelectricity has increased year by year. Its increase from 58.2 billion kWh in 1980 to 83 billion kWh in 1983 constitutes an average annual increase of 8.2 billion kWh. This not only provides large amounts of power for the national economy and for the people's livelihood, but also conserves oil and coal for power generation and is thus a positive contribution toward solving our country's energy shortage. Practice has proven that the strategic policy of the leading comrades in the Central Committee and the State Council to encourage the large-scale development of hydropower and to gradually shift the focus in electric power projects to hydroelectricity is absolutely correct. Having well proven its worth, hydroelectricity has bright prospects.

How was the output of hydropower increased so much, especially in 1983? There are objective and subjective reasons. As to the objective reasons, first, plentiful rainfall and abundant water inflow. Following 1981 and 1982, 1983 was the third year of abundant rainfall. In that year, rainfall in the southern provinces was heavy and came earlier than in previous years and lasted longer, which showed up most favorably in the hydroelectricity generated in the first half of the year. At quite a number of reservoirs of large hydroelectric stations, the sluice gates discharged large quantities of water in February and March. Record water levels were registered at the Xin'an, Xinfeng, and other reservoirs, one of the reasons for a very high level of power generation. In the north, the inflow of water into many reservoirs of hydroelectric stations was also fairly regular and on the whole sufficient for the needs of power generation, the abundance of water creating the physical base for the larger output of electricity. Second, the continuous starting up of new installations during the last few years was a major factor for the additional output of hydroelectric

power. For instance, the two hydroelectric power stations at Wujiangdu and Gezhouba started full power generation at the end of 1982 and the first half of 1983, respectively. The output from these two hydroelectric power stations reached 9.1 billion kWh in 1983, i.e., 10.9 percent of all hydro-power produced nationwide. The start of production at other hydroelectric power stations, such as Majitang and Nanya He, was also highly effective.

The subjective reasons include the attention paid by the leadership and the good coordination of hydro- and thermoelectricity. Since the promulgation in 1979 of the "Trial Regulations for the Implementation of Economic Regulation of Reservoirs at Hydroelectric Power Stations," the leadership at all levels of the power network and the regulatory departments paid great attention to the problem of how to best effect joint regulation and how to closely coordinate hydropower and thermopower. Depending on the season, and having formed a grid for large-scale hydropower and thermal power, all integrated into a power grid, forecasting, computations, and arrangements for many schemes were carried out, and preparations were made well in advance. Therefore, under conditions of heavy rainfall and inflow of water, the electricity network could more quickly arrange for thermoelectricity to reduce its load and regulate its peak, carry out effective measures to appropriately adjust and regulate economic norms for the peak load of fossil-fuel power plants and as far as possible let hydroelectric power plants discharge less water and generate more electricity. For instance, the Guangdong power network, with its limited installed capacity, has an extensive small-scale hydropower network and generates large amounts of power during the high-water season and the large-scale and medium-scale hydropower stations release large volumes of water. By encouraging the thermal power plants to adjust their peak loads and generate less electricity, hydropower output was increased by 200 million kWh, saving over 70,000 tons of coal and thus achieving an obvious economic success. When the inflow of water came ahead of the usual time at the hydroelectric stations of the Guangxi power network, the regulatory department promptly adjusted the transmission pattern of electricity from hydropower and thermopower plants. In March alone, the output of hydropower exceeded last year's output by 95 percent. Apart from this case, the power networks of East China, the Northwest, Hunan, and other areas also worked hard on the problem of how to increase hydroelectricity and to bring its generating capacity into full play. Second was the diligent attention given to forecasting, analyzing, adjusting, and giving full play to mutually complementary functions among groups of power stations. Doing a good job of forecasting water volume expected at the reservoirs, analyzing the precipitation and water conditions at the various hydroelectric stations, utilizing the disparity in mutual hydrologic and reservoir regulatory capacities, and carrying out, according to the intervals between water inflow, a mutual supplementation of water and electric power among the groups of hydroelectric stations, raising the rate of utilization of water volume for power generation and of the generating capacity throughout the network, are the important organic components needed to raise the volume of power output. The central regulatory offices for the power networks of Fujian, Hunan, and Guangdong have been very successful in this respect. The special characteristics of the hydroelectric stations of these three power networks

are: the regulating capacity of their reservoirs is not large, the regulating performances of the reservoirs are poor, and it is a painstaking and complex job to utilize forecasts, carry out systematic analyses and properly fix electricity output and volume for each power plant while ensuring reservoir safety. The regulatory departments of the three provinces and the responsible personnel at the various hydroelectric plants did solid and sincere work, cautiously, conscientiously, and diligently attending to forecasting, analyzing, and adjusting. They promptly expanded hydroelectric output and within limits retained the tail-end of the floodwaters, repeatedly using a portion of the reservoir capacity to attain the goal of increased hydroelectricity volume and achieved excellent results. Third, raising the level of operating the equipment and safeguarding good management. In recent years, the various hydroelectric stations have shown great improvement in maintenance of their generating equipment and in the quality of its overhaul; the number of hours that generating units could be reassigned increased. For instance, at times of high-water and large output, all machinery at the Liujiaxia Hydroelectric Station could be safely put into full operation. In 1983, to suitably meet the actual conditions of earlier-than-usual inflow of water, the various hydroelectric plants rushed repairs of any generating units under repair to enable earlier parallel generation of electricity by all units, reduce the release of unused water and achieve excellent conditions of operation. In the past, because the transmission line bottlenecks, electricity was wasted. In 1983 much improvement was effected in this respect. All the above activities added up to a firm guarantee for an increased hydroelectricity supply in the future.

Apart from the above-mentioned, the adjustment plans for improvement of reservoirs at hydroelectric stations, which had been seriously studied for the last few years by the scientific research departments and production regulating departments, are already being implemented, during limited periods of time, at certain electricity networks and have already achieved certain successes. However, because their application has not yet become widespread, there are still limitations in the extent to which they have been brought into play.

The above-stated conditions indicate that the record high level of 83 billion kWh of hydroelectricity achieved in 1983 is the result of both subjective and objective factors. It is also the result of joint hard work by such relevant sectors as hydroelectricity, thermoelectricity, regulatory adjustments, management, production, maintenance, capital construction, scientific research, hydrology, and meteorology. In the future, even closer cooperation is needed between all these sectors to achieve an even greater contribution toward the initiation of a new phase in hydroelectric power generation and toward raising the economic benefits from hydroelectric power generation.

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CSO: 4013/90

## HYDROPOWER

### STRESSING HYDROPOWER IN ENERGY RESOURCE DEVELOPMENT

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 1, 12 Jan 84 p 1

[Article by Chu Chenghai [0328 2052 3189]: "Comrade Wang Zhen [3769 7201] Points Out That Hydroelectric Power Will Be a Priority Energy Project"]

[Text] In October 1983, Comrade Wang Zhen, member of the CPC Politburo and president of the Central Party School, gave an important talk during an interview in his office with a group of students studying at the Hydroelectric Department of the Central Party School. He first enquired in detail about the overall plan for the utilization of the Hongshui He, what power stations are planned, what the capacity of the equipment will be, what investment will be required, when power supply will actually start up and what progress is being made. He said: Guangxi, where Comrades Deng Xiaoping and Wei Baqun [7279 2149 5028] carried out revolutionary activities, has a glorious revolutionary tradition. The basin of the Hongshui He is rich in products, has abundant coal resources and also large bauxite mines. However, its foundation for modern industry is weak. If we do a good job of carrying out a few key projects, we could solve South China's electric power shortage as well as promote the economic development of the area. We must speed up the development of the hydroelectric resources of the Hongshui He.

Comrade Wang Zhen went on to talk about the abundance of China's water power resources and the many advantages of developing hydroelectric resources. Hydroelectric power saves coal and is also beneficial for flood prevention, shipping, irrigation, aquatic breeding, etc. However, some comrades still do not completely realize all the advantages, but you, comrades, who concern yourselves with hydroelectric power must take the lead in propagating the important place that hydroelectric power occupies in the development of energy resources and must emphatically plead its economic benefits. When comrades talk of fully developing hydroelectric power and say that the state in its investments should let hydroelectric power "eat from the small cooker," he said, it is not a matter of "eating from the small cooker," we must rather line up hydroelectric power as a key energy undertaking.

Comrade Wang Zhen also enquired about plans for other river basins and the conditions of engineering projects. When he heard that over 250,000 personnel are engaged in hydropower projects throughout the country, but that due to



insufficient investments, there is surplus work capacity, and that if the state could increase investments, the speed of construction could be accelerated, he said: Waste of manpower is the most serious waste. That our country possess so large a contingent for hydropower projects makes me very happy, because that is the precondition for the speedy development of hydroelectric resources. We must also pay attention to bringing the role of the intellectuals into full play. If a technical cadre graduates from university in his early twenties and has a few years of experience, his thirties will be his "golden age." He can work as an engineer to his fifties, and from 50 to 70 he can be an excellent "professor," a technical consultant, and train middle-aged and young technical talent and sum up his experiences. In short, we must do a good job at implementing our policy regarding the intellectuals and bring their role fully into play. When some comrades reported about the harsh conditions at some of the engineering project sites, Comrade Wang Zhen said: We must advocate an attitude of waging arduous struggle and of "fearing neither hardship nor death." I have worked on railway construction and in the opening up of border areas: Where is there construction work that does not entail hardships? You must acquire a spiritual readiness to face hardships, must propagate the great significance of developing hydropower and its contributions to our country and our people.

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CSO: 4013/90

## HYDROPOWER

### WORK BEGINS ON FIRST-STAGE CONSTRUCTION OF TONGJIEZI

Chengdu SICHUAN RIBAO in Chinese 2 Jan 84 p 2

[Summary] Following a thorough overhaul of its political leadership and the implementation of an economic responsibility system, the 7th Engineering Bureau of the Ministry of Water Resources and Electric Power, the unit responsible for building the large-scale Tongjiezi hydroelectric power station has stepped up the pace of construction in order to prepare a solid foundation for the main part of the project.

In the building of the Tongjiezi hydropower station, it has not been possible to stick to the construction schedule because of a failure in 1983 to decide on construction plans and to resolve problems of relocating population and requisitioning land, so work on the first-stage flood control embankment and well, the antiseepage wall, the antislippage pilings, and other projects was delayed.

Following political reorganization, the Seventh Engineering Bureau reversed its passive condition, overhauled its production structure, established responsibility and contract systems, and implemented piece rate and floating wage structures. Leadership cadres at all levels sought to find first-hand solutions to problems. By the third quarter of 1983, the volume of work completed represented the highest level ever for the project. As of 15 December 1983, 60.22 million yuan, or 103 percent of the year's plan, had been spent. As part of the first-stage main construction, work on the caissons had begun 8 months before. Of these, caissons No 1 through No 4 had been sunk down to the rock ahead of schedule. The No 1 flood discharge tunnel is finished and a network of roadways on both the left and right banks communicating with the foundations and with the top of the dam and the log gates has taken shape. The Tongjiezi project's main route to the outside--the Sha-Zhen Highway--is now being widened along its entire length.

CSO: 4013/95

## HYDROPOWER

### FIRST MINIGENERATOR DEVELOPED, MAY SEE WIDESPREAD RURAL USE

Nanjing XINHUA RIBAO in Chinese 9 Dec 83 p 1

[Article: "Product of Scientific Research Will Make Small-Scale Hydropower Resources Available to Rural Communities"]

[Summary] China's first agricultural minigenerator was recently developed in Jiangsu Province and the equipment could be a boon to the development of hydraulic resources characterized by a sporadic availability, small volume of flow, and small head in a Chinese-style electrification of the countryside.

Last year, during an inspection of Fujian, Hu Yaobang talked of the full utilization of China's vast reserves of small-scale hydropower. The Nanjing Institute of Agricultural Mechanization subsequently organized hydropower engineers and technicians to make inspection tours of rural villages in Zhejiang, Fujian, Jiangxi, and other provinces. With support from all quarters, and in only 3 months' time, they came up with their first hydro-electric minigenerator.

This simply constructed piece of equipment weighs only 25 kilograms. It is easy to operate, can regulate voltage automatically depending on the peak load, and does not require expert technicians to operate it. All that is required is a head of about 3 meters in order to generate electricity. Each unit has an output of 600 to 750 Watts. Since it is compact, light weight, easy to set up and employ, and highly adaptable, it can be put to use in mountain springs, floodgates in dams, and even in irrigation canals and unused industrial water discharge gates. The unit is priced at around 400 yuan--easily within the means of the peasants.

The first unit was tested on the Shahe Reservoir, making use of water discharged over the spillways to generate electricity for lighting, cooking, and television. The unit was run continuously for more than 1000 hours. The second unit was operated by a production brigade in Liyang County, where it illuminated seven households. Finally, the Ministry of Agriculture, Animal Husbandry, and Fisheries directed the Jiangsu Department of Water Conservancy to convene an appraisal meeting at the Shahe Reservoir. Forty-five professors and experts gave the achievement very high marks, holding that it would have extensive value.

CSO: 4013/95.

## HYDROPOWER

### BRIEFS

HUNAN SMALL-SCALE HYDROPOWER--Changsha, 18 January (XINHUA)--Hunan Province has more than 9,000 small hydroelectric power stations with a combined capacity of 910,000 kilowatts. These small power stations generated 2.29 billion kilowatt-hours last year, 4 percent more than 1982. The 73 power stations built in 1983 were a contributing factor. Hunan takes third place in the development of small hydro-power stations in the country, which has more than 80,000 such stations with a combined capacity of 8.28 million kilowatts. Over 110,000 kilometers of transmission lines have been installed in Hunan as a result of the expansion of such power projects in the countryside. Forty-seven out of the 87 counties in the province have set up their respective power grids. [Excerpt] [OW181236 Beijing XINHUA in English 1213 GMT 18 Jan 84]

ZHANGZE POWER PLANT CONSTRUCTION--The Zhangze power plant project, a large pit-mouth power plant on the outskirts of Changzhi County, Shanxi Province, is under rapid construction. The project is planned to be completed by 1990. The power plant's generating capacity totals 800,000 kilowatts. [Summary] [Taiyuan SHANXI RIBAO in Chinese 1 Feb 84 p 1 SK]

LIAONING 500KV TRANSFORMERS OPERATIONAL--The eight 500,000-volt transformers, the largest ones of China, which were produced by the Shenyang Transformer Factory, have been successfully set up at their sites in Jinzhou and Liaoyang cities. They were put into operation on 27 January. The 500,000-volt power transmission line between Yuanbaoshan and Haicheng is the largest ultrahigh voltage power line in China. The line can convey all power turned out by the thermal Yuanbaoshan, Chaoyang, and Jinzhou stations to areas including Shenyang, Anshan, and Dalian cities. As compared with the 200,000-volt transformers used by the Northeast Electric Power Grid, these transformers may surpass the transforming capacity of the old ones by 100 percent. [Excerpts] [Shenyang Liaoning Provincial Service in Mandarin 2200 GMT 2 Feb 84 SK]

CSO: 4013/119

## THERMAL POWER

### SMALL-SCALE COGENERATION PLANTS COULD HELP PLUG ENERGY GAPS

Beijing JINGJI RIBAO in Chinese 2 Dec 83 p 2

/Article by Huang Yicheng /7806 3015 6134/, deputy director, State Planning Commission/

/Text/ To solve the severe electric power shortage problem, I believe that in addition to stressing the planning and construction of large- and medium-scale hydroelectric stations and large-scale thermoelectric plants, we ought to adopt definite policies and measures to mobilize the various power sectors to construct a large number of small-scale hydroelectric and thermoelectric stations. Here I will express my personal own views on the question of developing small-scale thermoelectricity to supply both heat and electricity.

Because condensing-type small-scale thermoelectricity has the disadvantages of low heat efficiency and greater investment/cost per kilowatt than large-scale thermoelectricity, some people feel that there is no future in developing it. Actually, the situation is very different with another kind of small-scale thermoelectricity--back-pressure thermoelectricity. It first uses steam to generate electricity and then uses this steam for industrial production or for residential heating. In this way, it totally recovers and uses the amount of heat that would otherwise be lost. This kind of thermoelectricity is called heat and power cogeneration.

This kind of small-scale thermoelectricity, capable of supplying both heat and electricity, has many advantages. The standard coal consumed in generating 1 kilowatt-hour is no more than 200 grams. Those that are systematically planned can reduce this amount to 150 or 160 grams. This is not only much less than the coal consumption with condensing-type small-scale thermoelectricity (which generally requires over 600 grams), but it is also much less than the consumption with 200,000- or 300,000-kilowatt condensing-type units (320-360 grams), and the heat efficiency is clearly improved. Seen from a cost perspective, apart from the required construction costs, back-pressure steam turbine boiler units are much simpler than condensing-type units. As this kind of electric generating station is built at electricity load centers, it is not necessary to spend money to construct long-distance transmission lines, and so you can save costs. The average investment per kilowatt is about one-half that of the large-scale thermoelectricity now constructed (including transmission and transformer facilities). Moreover, the construction period is also comparatively

shorter. Such an electricity generating station of 6,000 kilowatts or under can generally be constructed in 1 or 2 years.

In recent years, with the combined improvements in energy consumption technology and the change from oil-burning boilers to coal-burning boilers, we have made some headway in areas where the heat load is fairly concentrated by adopting methods involving the centralized production of both heat supply and thermoelectric generation, so as to transform anew the small and middle sized boilers that were scattered and out-of-date. The chemical fertilizer plant in Jiangning County, Jiangsu, was originally equipped with four small 4 to 7-ton, low-temperature, low-pressure oil-burning boilers, used to produce steam for chemical fertilizer production. Later, they replaced the four small boilers with one fairly high-efficiency, 20-ton boiler, with a steam pressure of 52 kilograms and a temperature range up to 470°C. At the same time, they added one small 2,300-kilowatt back-pressure thermoelectric unit. The result was that while basically not increasing the fuel supply, they not only guaranteed steam for production use, but produced over 2,000 additional kilowatt-hours of electricity. Another example is the 13 plants in Shandong's Zhangdian chemical industry zone. Each plant had constructed a boilerroom to supply heat. Due to the expansion of production in recent years, their heat supply capacities were inadequate, so one after another, they demanded the expansion of the heat supply boilers for their own plants. Under the unified plan of the city's Planning Commission, they set up two 100-ton boilers and a 255,000-kilowatt back-pressure heat supply unit. In this way, they conserved fuel, increased electric power, and reduced environmental pollution. That is really killing three birds with one stone.

You can see from the above examples that all areas that have heat consumers can develop this kind of small-scale thermoelectricity. The size of the operation should be determined according to the amount of heat used. With this kind of electricity generating station, construction is easy, the expense is not great, and the domestic technology and facilities have long since met the standard required. Various areas and enterprises can carry out construction according to their own circumstances, fitting measures to local conditions and relying primarily on their own resources.

According to statistics for 1981, nationwide there are 200,000 boilers for industrial use and heating use, with a total of over 420,000 steam tons. In 1982, this number was increased by over 10,000 boilers with a total capacity of 35,000 steam tons. With the expansion of industry and of residential construction, the amount of heat use has really provided very good conditions for developing small-scale thermoelectricity generating stations to supply heat. Even though we can not use a heat-supply amount of over 400,000 steam tons capacity to develop electric generating stations to supply heat, we most certainly can use a part of them that have the proper prerequisites in order to carry out planned transformation. To can get the most immediate results and the quickest profit, we must first get control of the boilers that are newly built each year, and to the greatest extent possible see that they combine heat supply and electricity supply. In that way, we will obtain rather considerable amounts of electric power. By my rough calculations, if we raise both the pressure and temperature of the boilers, with cogeneration, each ton of steam supplied will produce roughly 100 kilowatt-hours of electricity, on the average. In this way, with 10,000 steam tons of steam, they can get 1 million kilowatts of electric power!

To promote the smooth development of this type of small-scale thermoelectricity, I propose the following:

1. Newly established enterprises and residential areas should use centralized heat-supply methods to the greatest possible extent, to facilitate the selection and use of relatively large-scale boilers. Moreover, based on technological and economical rationality, they should raise the pressure and temperature of the boilers to allow the steam produced by the boilers to first be used to generate electricity and then used to supply heat.
2. We should demand that machine manufacturing departments be able to serialize production parameters to fit small thermoelectric facilities that supply both heat and generate electricity, giving consumers a choice.
3. When no special circumstances apply, we should demand that all design institutes no longer accept design assignments for boiler rooms that only supply heat without also generating electricity.
4. We should adopt suitable policies to solve the various problems of fuel supply, the handling of surplus electric power, and sources of funds, and actively support the smooth development of small-scale thermoelectric cogeneration.

12452

CSO: 4013/70

## THERMAL POWER

### GROUNDWORK FOR BAIMA EXPANSION PROJECT COMPLETED

Chengdu SICHUAN RIBAO in Chinese 23 Oct 83 p 2

[Article by Li Yongtong [2621 3057 1749]: "Baima Power Plant Forms Strong Leadership Team, Carries Out Early Stage Preparatory Work for Expansion Construction Project"]

[Excerpt] After organizing a powerful leadership team, the Baima Power Plant has completed early stage preparatory work for the expansion project for two 200,000 kw generators.

In Sichuan, where the primary power network is mainly hydroelectric, there is rarely a shortage of power in high-water periods, but during dry periods there are serious shortages, thus regulatory ability is deficient and this has a major influence on the growth of industrial and agricultural production. The Baima thermal power plant expansion project is a very important construction project to improve Sichuan's power supply situation. It is at the heart of Sichuan's primary power network and is the center where the important power source points of hydropower and thermopower connect; adding two 200,000 kw extra-high voltage generators here will play an important role in improving the entire power network, in electrifying the Chengdu-Chongqing railway line and in developing Sichuan's industrial and agricultural production during the Seventh Five-Year Plan.

To improve construction of this important project, the Baima Power Plant promptly transferred a chief engineer, a deputy chief engineer, and a team of technical and managerial cadres, organizing a powerful leadership team. In May of this year, the Expansion Construction Office was established and a senior officer responsibility system put into effect. The members of this leadership team are mostly people who graduated from college in the sixties. They have a wealth of experience, high work efficiency, and a no-nonsense approach. The Construction Office established four sections for planning, technology, materials and equipment, and finance, and a general office. Each department has drawn up responsibility regulations and implemented an assessment system combining authority, responsibilities, and interests. This team has the courage to assume heavy burdens and to take the initiative. They have never built a 200,000 kw extra-high voltage generator before, but they will learn as they build. They have stressed making the



technological preparations and sent people to other power plants and related manufacturing plants to carry out special investigations, collect materials, and study experience. At the same time, they have taken the initiative to coordinate closely with the design unit and constantly exchange views. Through full preparations they have put forth preliminary design proposals, quickly achieving agreement and avoiding wrangling and delays. They have also taken the initiative to make information exchange contacts with over 10 sections and units at the national, provincial, regional, and municipal level and in a short period of time became well grounded on questions of fuel, transport, environmental protection, securing water, and equipment and also reached agreement on resettlement and procuring land.

8226

CSO: 4013/74

## THERMAL POWER

### BRIEFS

WORK ON ZHANGZE BEGUN--Taiyuan, 15 Mar (XINHUA)--Work began today on a 1 million kilowatt thermal power plant in southeastern Shanxi Province. Construction of the Zhangze plant, near the industrial city of Changzhi and a large reservoir, will be completed in two stages. Two 100,000-kilowatt generating units will be installed in the first stage and will go into operation in 1985 and 1986. Electricity will be provided to the Shanxi Chemical Fertilizer Plant, which will produce 900,000 tons of phosphate fertilizer annually on completion in 1986, the electrified railway line between Changzhi and Jiaozuo in neighboring Henan Province and two coal mining areas in Shanxi. Generating units with a combined capacity of 800,000 kilowatts will be installed by 1990 in the second stage of construction, supplying electricity to Shandong Province and other areas. [Text] [OW152140 Beijing XINHUA in English 1444 GMT 15 Mar 84]

ANSHAN CONSTRUCTION BEGINS--Construction of the Anshan City thermal power plant in Liaoning Province started on 12 March. The project involves two 1,200-kw generating units and three 75-ton steam boilers. The annual generating capacity is 116 million kWh and the annual heat supply is 7 billion kilocalories. The project will be completed by the end of 1986. [Summary] [SK190913 Shenyang Liaoning Provincial Service in Mandarin 1030 GMT 12 Mar 84]

ZHEJIANG POWER PROJECT--Hangzhou, 15 Mar (XINHUA)--Work began today on the second-stage construction of a key thermal power plant in Taizhou, Zhejiang Province. In the present stage of construction, two generating units with a capacity of 125,000 kilowatts each are to be installed at the Taizhou thermal power plant in southern Zhejiang. Designated as a key energy project by the state, the Taizhou power plant already put into operation two generating units with the same capacity last year. It has already been linked to the east China power grid embracing Shanghai, Jiangsu, and Zhejiang. When completed by 1986, the plant will produce 2.8 billion kWh of electricity a year. One of the impediments to economic growth in Zhejiang is the shortage of energy. To ease the strain on power supply, a 200,000-kilowatt hydroelectric power station is being built and more thermal power stations are under construction in the province. [Excerpt] [OW151138 Beijing XINHUA in English 1030 GMT 15 Mar 84]

CSO: 4010/65

## COAL

### FOREIGN HELP NEEDED IN DEVELOPING HUGE STRIP MINES

Beijing KEXUE SHIYAN [SCIENTIFIC EXPERIMENT] in Chinese No 12, 10 Dec 83  
pp 4-5, 25

[Article by Lu Lin [6424 7207]: "China's Open-pit Coal Mines"]

[Excerpt] Open-pit mining techniques have progressed rapidly in the 20th Century and there have been great developments in open-pit mining. In 1913, before World War I, coal taken from open-pit mines throughout the world was only 6.6 percent of the total extracted. By 1952 this figure had increased to 24.9 percent and is now even higher at more than 30 percent.

Before Liberation, open-pit mining techniques in China developed slowly as a result of the influence of the plundering of the natural resources by imperialism. Mining techniques and equipment were very backward. Following the growth of industrial construction in the nation, there was rapid development of open-pit mining. In the area of open-pit mining in the early period after Liberation, not only was there production in large open-pit mines such as the Fushunxi open-pit mine, there was also construction of the completely new and world-famous Buxinhaizhou open-pit coal mine with an annual output of more than 3 million tons.

China is a vast country with abundant resources, and there are many mineral resources suited to open-pit extraction. In terms of the overall coal industry, although the proportion of open-pit mines is small at present (only 4 percent of total output), the pace of development of open-pit coal mining will be greatly accelerated along with future development of the national economy.

#### Favorable for Rapid Development

Open-pit coal mines have many advantages over underground coal mines. First, open-pit production is carried out over a broad area, which facilitates the use of heavy machinery and equipment. Second, it is possible to make full use of underground resources and there is a high percentage of recovery of coal deposits. At the same time, whenever there is a secondary mineral deposit it can also be extracted. For example, when coal is extracted from the Fushunxi open-pit mine, there is also stripping and production of oil shale (which was created with the coal seam) to supply to petroleum refineries

for refining synthetic petroleum. The waste oil shale can also be used as a mine pit fill material, thereby killing several birds with one stone. Third, work conditions in open-pit mines are better and safer than in underground mines. Fourth, the space left after open-pit extraction does not require special supports, which can save a lot of mine timber. Under normal conditions, the amount of mine timber consumed in open-pit mining is only about 5 percent of that in underground mines. Thus, when the coal seam is shallow and is buried fairly evenly, great efforts should be made to give consideration to adopting open-pit mining patterns.

The above advantages of open-pit mining are quite obvious. In an open-pit mine coal extraction and shipping can be accomplished merely by stripping off the overburden above the coal seam before the seam is extracted.

Before stripping away the rock and extracting the coal, there must first be scientific classification of this rock according to hardness. The overburden is usually stripped by using explosives. This requires the selection of suitable drilling machines and rigs according to different degrees of hardness of the rock. Next, ammonium nitrate-oil is placed in the bore holes after they are properly arranged and then detonated using blasting caps, primacord, or other detonator. This saves a great deal of labor over underground mining, in which shafts and tunnels are bored and drilled.

After being blasted or loosened mechanically, the rock and coal are moved elsewhere by excavation and stripping machinery and equipment and trucks. This is the most important link in open-pit mine production. Drilling the holes, blasting, shipping, and removing the overburden are carried out around the extraction and loading operations. Extraction and loading work is mainly accomplished mechanically with equipment such as draglines, bucket-wheel excavators, and power shovels. The question of what type of equipment is most suitable for use in an open-pit mine is determined by the nature of the rock, the burial conditions of the ore body, climatic conditions, the availability of equipment and parts, and other factors. For example, current open-pit coal mines in China are fairly deep, the coal and rock to be stripped and excavated is of medium hardness or greater and the coal seams are inclined. They generally use mechanical shovels for extraction and loading and are linked with rail transportation. The conditions of this process are far superior to having to dig out the coal seams in underground coal mines.

In open-pit mines, the coal and rock which is excavated and loaded by machine must be taken from the place where it was stripped and excavated and shipped to a crushing yard, ore separation yard, or ore unloading station. At the same time, a large amount of overburden must be shipped to a slag pile and dumped. Moreover, material, equipment, and personnel must be brought in. For this reason, transportation plays a key role in open-pit mine production. Currently used transportation methods include railroads, trucks, conveyor belts, slope hoisting, and slurry pipe lines. Each of these transportation methods has its own special characteristics. Railroad transport, for example, has a great shipping capacity and the ton

kilometer shipping cost is low, which is highly suited to the nature of coal and rock. It is better suited to shallow large open-pit mines with simple terrain and a large quantity to be transported. Truck transport is flexible, the placement of lines is simple, and steeper grades are possible. It is more suited to open-pit mines with a small area, short transportation distances, and complex ore body structures and shapes. Conveyor transport has a large hauling capacity and can be used on steep grades. It is suited to open-pit mines with loose coal and rock. This process is much simpler than hoisting the coal to the surface in underground mines. In summary, when compared with underground mining, open-pit extraction not only has lower costs and higher output, but labor efficiency is also much higher. This provides favorable conditions for rapid development of the coal industry.

Of course, open-pit mining also has its special characteristics, such as the need to deal with the large amount of overburden that is stripped away. A great deal of earthmoving work is required to dump this overburden at a slag pile away from the mine. This is mainly accomplished by using small earth scrapers, excavators, bulldozers, conveyors, and other such equipment. Earthmoving techniques are selected according to the type of mining and transport equipment, the nature of the soil and rock to be dumped, the required earthmoving capacity, the location of the slag pile, and other factors. Currently, the most used method is mechanical shovelling and dumping of the earth. In the earthmoving process, as large areas are involved, consideration must also be given to questions of pollution of the ecological environment. Along with the development of open-pit mining, more and more land will be covered with the dumped overburden. The slag piles of large open-pit mines in China usually cover more than 10 square kilometers, and competition for land with agriculture has appeared in some mining districts. At the same time, from the perspective of maintaining a balance in the ecological environment, there must be proper arrangements for land restoration so that it may be used for cultivation. Currently, research on land restoration has not been undertaken in open-pit mining in China in a major way. This work is quite comprehensive and requires careful attention as well as emphasis on rational development according to local conditions. There are also disadvantages in open-pit mining such as the need for large-scale machinery and equipment, the occupation of large amounts of land and great susceptibility to climatic influences, as well as fairly strict requirements for the burial conditions of the mineral deposits. These all require consideration and proper arrangements in the process of opening up open-pit mines.

#### It Is Imperative

The total national annual industrial and agricultural output value must be quadrupled in the 20 years between 1981 and the end of this century, and coal production must increase from an annual output of around 600 million tons to an annual output of 1.2 billion tons. In his "Report on the Sixth Five-Year Plan," Comrade Zhao Ziyang pointed out that efforts should be concentrated on opening up large open-pit mines at Huolinhe, Yiminhe, Pingshuo, Yuanbaoshan and Jungar (see map). This major policy decision is based on

the actual conditions of open-pit coal mines in China. China has a lot of widely distributed resources suitable for open-pit mining with proven reserves of 53 billion tons. The five large open-pit mining districts listed above have accurately proven reserves of 10 billion tons. Additional proved reserves of 5 million tons may be submitted before 1985. Open-pit mining experts feel that open-pit exploitation may be considered when the stripping-ore ratio for open-pit stripping of soil and rock is less than 10. Most of the five major open-pit mining districts in China have a stripping-ore ratio of 4 to 6, relatively good conditions for exploitation.

Open-pit extraction conserves investments, produces more coal, and creates faster results. For example, the Buxinhaizhou open-pit mine which was constructed during China's First Five-Year Plan had an annual design capacity of 3 million tons, and the investments required for a ton of coal were 11 percent lower than large-scale shaft mines constructed during the same period. The construction period was 33 months, which was 42 percent less than the 56 months needed for construction of the Ping'anli Mine (annual output of 1.5 million tons). Looking at statistical data from foreign countries from the 1960's to the 1980's, 84 percent of the increase in coal in America and 81 percent in the Soviet Union came from open-pit extraction. In the past decade, there has been a net increase of 200 million tons in open-pit production in America and 100 million tons in the Soviet Union. It may be seen from this that if conditions permit, priority to opening up open-pit mines is very beneficial for accelerating development of the coal industry.

At present, the prologue to opening up large open-pit coal mines in China has begun--construction has been speeded up at Huolinhe, and the stage of stripping the coal seam has been partially reached; Yiminhe will also go into operation soon and preparations for construction at Pingshuo, Yuanbaoshan and Jungar have also been speeded up. The overall situation is quite good.

#### Construction Progress

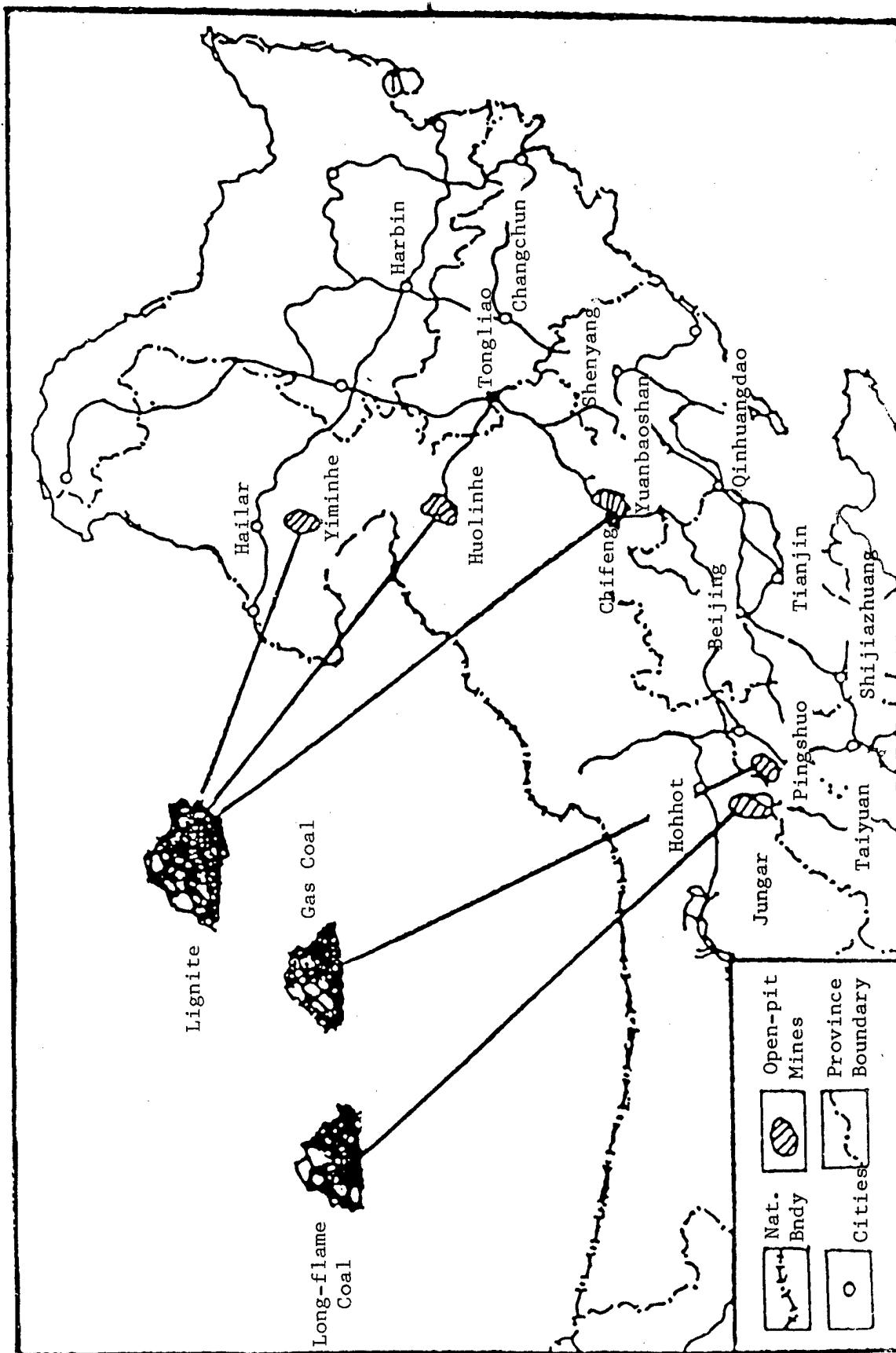
In the more than 30 years since the founding of the nation, China has constructed a group of large, medium and small-scale open-pit coal mines, and much experience has been accumulated during production practice. A specialized technical contingent for opening up open-pit coal mines has also been formed. Metallurgical, chemical and other sectors in China have also accumulated much experience in developing open-pit mines which can be drawn upon when opening up open-pit coal mines. For these reasons, there are fairly good conditions at present for developing large-scale open-pit mines and rapid progress can be made in construction.

The main link in constructing large open-pit coal mines is the outfitting of large-scale technical equipment such as large power shovels, bucket-wheel excavators, dump trucks, conveyors and so on. China cannot manufacture large amounts of such heavy equipment, but the problem can be resolved by cooperation with foreign countries, importing prototypes and organizing domestic

assimilation and manufacture. Furthermore, in the area of mining techniques, valuable experience in open-pit coal extraction under extremely cold conditions below minus 30° Centigrade has been gained in large open-pit mines like that in Huolinhe. Of course, China's experience in developing large-scale open-pit coal mines is still inadequate, especially in shipping out large amounts of coal, which is especially difficult. How can this be resolved to greater advantage? Local use for generating electric power, establishing pit-mouth power stations, joint management of coal mines and power stations, integration of railroad and pipe line transport, using heavy coal-hauling trucks and other means are all schemes which may be considered.

[Map on next page]

Map of Locations of the Five Major Open-Pit Coal Mines





COAL

# SHANXI TO TRIPLE COAL SHIPPING CAPACITY BY 1990

OW111207 Beijing XINHUA in English 1030 GMT 11 Feb 84

[Text] Taiyuan, 11 February (XINHUA)--Shanxi's roads and railways will be able to ship more than 400 million tons of coal by the year 1990, nearly three times their present capacity, provincial governor Wang Senhao told XINHUA.

Railways in Shanxi, the country's leading coal producer, currently handle about 130 million tons a year. Highways of the north China province take an additional 10 million tons, lagging far behind the figure which needs to be shipped out.

By the end of last year, 27 million tons of coal were piled up in collieries and freight yards by the transport blockade. The province cut a total of 157.4 million tons of coal in 1983, about 22.4 percent of the national total.

The central government has invested an average of 1 billion yuan a year (about 500 million U.S. dollars) in mine and railway construction in Shanxi. More will be invested this year, said Wang, a former senior coal mining engineer. Moves are also under way to boost the annual capacity of the province's six railway outlets to 220 million tons a year, he added.

Work will begin soon on three new railways with an aggregate capacity of 210 million tons, he said, including China's first special double-track electrified line. Starting from the Datong coal mining administration, the largest of more than 80 in the country, it will terminate at the port of Qinhuangdao in Hebei. The 630-kilometer railway is designed for trains of between 6,000 and 10,000 tons. After its completion in 1987, it will handle 100 million tons of Shanxi coal.

The province also plans to build or upgrade ten major highways by 1988 for an additional freight capacity of 30 million tons. Work will start on four such highways this year, Wang said.

CSO: 4010/55

COAL

SHANXI CREATES COAL RESOURCES COORDINATING COMMITTEE

HK171558 Taiyuan Shanxi Provincial Service in Mandarin 2300 GMT 16 Feb 84

[Text] To strengthen the unified management and rational exploitation of coal resources throughout the province and to ensure the coordinated development of all kinds of coal mines and smooth progress in the building of coal, energy, and heavy and chemical industrial bases, the provincial people's government decided to establish the Shanxi Provincial Coal Resources Management Committee.

The main tasks of the Provincial Coal Resources Management Committee are:

1. To unify the planning of coal resources throughout the province in accordance with our province's plan for the development of the coal industry, it is necessary to make a rational division of controlled coal mines, and commune and brigade coal mines.
2. To organize in a unified way the oilfield prospecting forces throughout the province and to strengthen the work of prospecting for coal resources throughout the province.
3. To be responsible for the unified management of coal resources throughout the province, to handle and approve applications for the use of coal resources, and to issue coal resources exploitation permits.
4. To formulate and to implement local laws and regulations concerning coal extraction.

The Shanxi Provincial Coal Resources Management Committee is under the direct leadership of the provincial people's government. Vice Governor Yan Wuhong is concurrently chairman of the committee. The committee has officially commenced work.

CSO: 4013/109

COAL

LIAONING TO ACCELERATE DEVELOPMENT OF SHENYANG FIELDS

OW261142 Beijing XINHUA in English 0630 GMT 26 Feb 84

[Text] Shenyang, 26 February (XINHUA)--Liaoning Province, a heavy industrial center in northeast China, will speed up the development of the Shenyang coal field as part of its effort to ease the energy shortage, Vice-governor Wang Guangzhong said today.

Covering about 520 square kilometers, the field is near the industrial cities of Shenyang, Benxi, Liaoyang and Anshan. Its coal reserves are assessed at 2 billion tons.

A mine designed to produce 900,000 tons annually is scheduled to go into operation next year, the vice-governor said. Construction of another nine mines will be completed by the end of the century, raising the field's present annual output from 4.5 million tons to 12.2 million tons, he added.

From 1984, he said, the field's production is expected to rise at an annual rate of half a million tons, increasing the province's industrial output value by 500 million yuan (about 250 million U.S. dollars) a year.

Eight mines in the field produce coking coal, anthracite, and brown coal. There are also three coal washing plants.

Liaoning Province has to ship in 21 million tons of coal annually from other parts of the country, equivalent to 45 percent of its total coal consumption, the vice-governor said. Even so, the energy shortage causes a loss of 7 billion yuan in industrial output value, and 1.64 billion yuan in taxes and profits to the state, he added.

CSO: 4010/55

COAL

#### LARGE COAL FIELD DISCOVERED IN XINJIANG

OW280418 Beijing XINHUA in English 0256 GMT 28 Feb 84

[Text] Urumqi, 28 February (XINHUA)--A large coal field with an estimated 9.6 billion tons of [reserves] has been discovered in the eastern part of the Xinjiang Uygur Autonomous Region, according to the regional bureau of geology and mineral resources.

Lying in the Hami Basin south of the Tianshan Mountains, the Dananhu [field] covers an area of 114 square kilometers. The coal seams are 40 to 70 meters thick, in some sections 180 meters thick.

Two [other] large coal fields have also been discovered in the past 2 years on the fringes of the Junggar Basin in northern Xinjiang: one covers 66.5 square kilometers and contains 3.1 billion tons of coal. The seams average 39 meters thick; the other contains 5 billion tons of coal and the seams' thickness is 62 meters.

Taking up one-sixth of the area of China, the Xinjiang Uygur Autonomous Region now has known coal reserves of 17.4 billion tons, deposited in a dozen places. Geologists estimate that Xinjiang has 1,600 billion tons of coal, outstripping the country's largest coal producer, Shanxi Province, and accounting for one-third of China's total coal reserves.

In 1983, Xinjiang cut more than 12 million tons of coal. In recent years, Xinjiang shipped some 1 million tons of coal a year to the rest of China.

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## COAL

### BRIEFS

RECORD JANUARY OUTPUT--Beijing, 11 Feb (XINHUA)--China's mines produced 62.11 million tons of coal in January, 5.13 million tons over the target set for the month and 4.08 percent greater than the same period in 1983, coal ministry officials said here today. Daily output for January was 2 million tons, an all-time high, they said. China's major mines cut 34.07 million tons last month, 2.23 million tons above the planned figure and 4.7 percent more than January 1983. China produced 700,326 million tons of coal last year, hitting targets set for 1985 under the Sixth Five-Year Plan (1981-1985) 2 years ahead of schedule. Provisional plans call for an output of 710 million in 1984, the officials said. Shanxi Province, the country's leading coal producer, cut 157.4 million tons in 1983, 22.4 percent of the national total. Its major coal mines turned out 6.93 million tons, a 6.18 percent rise over January 1983 and a new record high. [Text] [OW110913 Beijing XINHUA in English 0645 GMT 11 Feb 84 OW]

SHIZUISHAN BOOSTS OUTPUT--The Shizuishan Mining Bureau in Ningxia is greatly increasing its output of raw coal. Within a space of 4 years and at a cost of less than 30 million yuan, the Bureau's overall production capacity has risen from 1.95 million to 2.55 million tons of raw coal [a year]. [Excerpts] [Beijing RENMIN RIBAO in Chinese 28 Jan 84 p 2]

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## OIL AND GAS

### NATIONAL FIRM FORMED TO PROVIDE OIL FIELD SERVICES

HK280040 Guangzhou GANG'AO JINGJI in Chinese No 1, 1984 pp 2-5

[Article by Hu Yi [5170 5030]: "The Headquarters of the Support Services for Exploitation of South China Sea Oil Fields"]

[Text] I. The Organizational Features of the National Corporation of the Support Services for the South China Sea Oil Fields

The National Corporation of the Support Services for the South China Sea Oil Fields was set up in May 1982. This corporation was jointly set up by the Ministry of Petroleum Industry and the Guangdong provincial people's government. It is independent of the Nanhai East Oil Corporation and the Nanhai West Oil Corporation of China, which it serves.

Having a department's service organization be independent of its production organization and forming a system of specialized organizations of equal rank are ideas unprecedented in China. In the past, in our effort to exploit oil resources on land, we have created a "Daqing style" of management. Daqing is an enterprise as well as a "society." The headquarters of Daqing is the supreme command for both the production system and service system, and has the slogan, "Daqing is production first, life second." Consequently, the basic ranks in production and transportation systems are made up of workers, while the basic ranks in life and the service system are composed of dependents of these workers. Following the inflow and expansion of these dependents, the life and service system has been gradually perfected. And with the establishment of such facilities as dining halls, hospitals, schools, kindergartens, and shops, and even a bedding and clothing factory and farms, Daqing has consequently been built into a new city that has both urban and rural features.

The "Daqing style" of management is a product of a particular era. And under the historical conditions at that time, it was no doubt effective and has written a brilliant page in the history of industry in China. But it may not be applicable to the exploitation of offshore oil resources. The exploitation of offshore oil resources has its own character and therefore it [word indistinct] a new service system. This character is mainly shown in the following two areas.

First, the exploitation of offshore oil resources is more difficult than on-land oil resources. It requires more advanced technology and a higher service

level. Many things that are indispensable to offshore oil exploitation, such as air transportation, sea transportation, meteorological and oceanic conditions forecasting, underwater salvage, and radio telecommunications are not required in on-land oil exploitation, or are not important. The exploitation of offshore oil resources requires that the various related service items must be closely coordinated to form a complicated but complete system.

Second, in exploiting offshore oil resources, it is imperative to cooperate with foreign companies because such exploitation needs huge investments and advanced technology. Through such cooperation, we will be able to utilize the capital and technology of these companies to accelerate the speed of exploitation. Consequently, to a certain extent, the main targets of the support services for the exploitation of the oil resources are foreign companies and foreigners. This situation means that the services must be "on time" and "of high quality." Foreign enterprises pay a lot of attention to the utility rate of capital and equipment. The rigs used by these companies are leased from other companies at more than \$100,000 a day. If supplies cannot be provided on a timely basis; therefore, these companies are most concerned with "timely" services. Foreigners do not advocate production first and life second. In addition, their lifestyle and standard of living are different from ours. They have particular and higher demands from our services in such areas as the basic necessities of life, medical treatment, education, and recreation, and consequently our services must be of a "high quality."

In order to meet the above-mentioned requirements, the State Council has decided that the production system and service system of the exploitation of offshore oil resources must be managed separately and developed in parallel. The Corporation of the Support Services for the South China Sea Oil Fields was formed against this background. Its formation is characterized by the following three features.

1. Specialization. Specialization first means "specialty." And the tasks of the National Corporation of the Support Services for the South China Sea Oil Fields include serving oil exploitation. This service differs from social services in general. Specialization also means division of work. The National Corporation of the Support Services for the South China Sea Oil Fields has various specialized subsidiaries which are responsible for providing different support services to meet the needs of the sophisticated technology that is required in exploiting offshore oil resources and to enable the exploitation to be carried out efficiently and to be of a high quality.

2. Socialization. The services that are required in the exploitation of offshore oil resources are enormous and complicated and the National Corporation of the Support Services of the South China Sea Oil Fields has cooperated with the related provincial and municipal bureaus and jointly set up specialized companies and base companies so as to make full use of the existing social force. Although these companies are independent enterprises, each having their own business responsibilities, they have been unified through the coordination of the National Corporation of the Support Services for the South China Sea Oil Fields into one big entity with a specialized goal and socialized contents.

3. Localization. The National Corporation of the Support Services for the South China Sea Oil Fields is under the dual leadership of the locality and a higher department, with the Guangdong provincial leadership taking the main role. The activities of the corporation are supported by the province by means of manpower, material power, and financial power. These activities have also promoted the economic development of the province. To view it from the point of the organizational features of the Nanhai West Oil Corporation and the National Corporation of the Support Services for the South China Sea Oil Fields, it can be seen that localities are responsible for production, while the provincial government is responsible for services.

## II. The Roles and Tasks of the National Corporation of the Support Services for the South China Sea Oil Fields

According to conservative foreign estimates, the oil deposits of the South China Sea can be exploited for 100 years. Therefore, from a long-term point of view, the National Corporation of the Support Services for the South China Sea Oil Fields has the following three tasks.

1. Serve the survey, exploitation, and production of offshore oil resources and see that oil will be produced. This is the most direct task of the national corporation.
2. Recover part of the capital. The exploitation of the oil resources in the South China Sea is expected to require \$20 billion in investments in 10 years. And in our joint exploitation with foreign companies, foreign investments will be compensated in the form of oil. China will share 51 percent of the profits from oil production while the remaining 49 percent will be shared by foreign companies. This means that enormous wealth will flow out of China to other countries. As owners of oil resources, we can take advantage of this particular position and recover part of the capital by providing services for the exploitation of offshore oil resources.
3. Provide economic aid to rear areas, promote the economic development of the coastal areas of the oil fields, and build complete ranks of workers for the offshore oil industry.

But it is not easy to complete these tasks.

First, it is true that as owners of oil resources, we have the right to provide services, yet we can in no way resort to a bureaucratic style of business; nor can we force foreign companies to accept our services. They can be attracted only if we are able to offer highly efficient and good quality services. Some staff of foreign companies bluntly said that if our services leave much to be desired, they would rather seek services from Hong Kong even though it would be troublesome to do so. As the various trades in Guangdong Province that are providing services for oil exploitation still lack experience and their equipment is backward, the National Corporation of the Support Services for the South China Sea Oil Fields has consequently put forth the principle of "internal unity and external cooperation." That is, while measures are taken to unite the specialized departments concerned in the province and



the rest of the country, it is also imperative to cooperate with foreign, Hong Kong, and Macao companies in a bid to import advanced technology and management. The National Corporation of the Support Services for the South China Sea Oil Fields has set up joint ventures with foreign, Hong Kong, and Macao companies with regard to such aspects as shipping, air transportation, and telecommunications and has also imported equipment.

In addition, China is introducing planned economy as the main factor. Although the services for the exploitation of offshore oil resources will bring economic aid to rear areas, this business can in no way be undertaken rashly. That is why the National Corporation of the Support Services for the South China Sea Oil Fields put forth the eight-character principle of "unified arrangement, coordination, organization, and supervision." With this principle, the various related enterprises in and outside the province have been organized to coordinate their actions in providing services. On the other hand, measures are also being taken so that these enterprises will be able to coordinate and consequently prevent repetitious construction and multiple leadership in dealing with foreign companies and waste of state capital. The following principles have been adhered to in making unified arrangements and carrying out coordination:

1. Preference is given to the related enterprises in Guangdong Province and enterprises of other provinces are not considered when the province itself is able to provide the required services. If the services are beyond the capability of the province, other provinces and central government departments concerned will be welcomed to provide the services, and to cooperate and render support.
2. Specialized companies are allowed to import technology and equipment and cooperate with foreign companies. But when it is within the capability of China, consideration will be given primarily to the utilization of the equipment and services that can be provided by the country.
3. There would be no subordinate relations for the companies that are taking part in bidding (including companies that have cooperated with foreign companies). That is, all bidding companies are treated equally and there should be no monopoly and squeezing others out. Such measures are necessary to encourage competition.
4. The specialized companies (including joint ventures with foreign companies) that have made bids for the five items of aircraft, vessels, telecommunications, bases, and navigation are not allowed to transfer these items to foreign companies.
5. The National Corporation of the Support Services for the South China Sea Oil Fields will direct the various related companies of the country in defining the bidding price on the basis of the study of international prices. The bidding price should be slightly lower than the service prices offered by other companies in Southeast Asia and Hong Kong so that the pricing can be based on the principle of guaranteeing capital with marginal profits.

6. The contradictions among specialized companies will be coordinated and resolved by the national corporation while conflicts with foreign companies will be reported to the China National Offshore Oil Corporation.

### III. The Organizational Structure of the National Corporation of the Support Services for the South China Sea Oil Fields

The National Corporation of the Support Services for the South China Sea Oil Fields is composed mainly of the following three parts.

The first part is the functional department, which is made up of six sections: administrative section, personnel, professional section, development, liason, and finance. The tasks of this department include working out overall planning, organizing and coordinating the support service activities in all of the South China Sea oil fields, and raising capital.

The second part is the base company. The national corporation now has three united base companies in Guangzhou, Zhangjiang, and Sanya, with the Guangzhou and Zhanjiang bases being of a considerable size. The base company in Guangzhou is now in a position to provide accommodations in a dozen luxury hotels. It has also arranged four hospitals to provide medical services, and has built a swimming pool, children's recreational facilities, and a kindergarten.

Arrangements have also been made with a number of primary and secondary schools with a higher education level. In addition, a total of 30 specialized vehicles are available, with English-speaking drivers. The base company in Guangzhou is planning to build a luxurious and complete Jinhua housing area that will have recreational and shopping facilities and be of considerable size. Facilities such as a central oil building, cultural center, food-processing factory, dairy farm, beef cattle farm, and a support and supply base will be located at Miaotou, Huangpu. The Zhanjiang base is now composed of 20 villas, 100 suites for singles, and other complete facilities, such as restaurants with Chinese and Western cuisine, a supermarket, swimming pool, and schools. In addition to Guangzhou, Zhanjiang, and Sanya, the national corporation has also established the Chiwan oil base company by offering shares.

The third part represents specialized companies, consisting mainly of the following:

A labor company, which is responsible for recruiting and training specialized staff, such as maintenance workers, supplementary rig workers, telecommunications operators, drivers, interpreters, cooks, doctors, and kindergarten teachers for foreign companies to employ.

A goods company and life service company, which are responsible for purchasing various means of production and subsistence that are required for oil exploitation. Following approval from the central government to the Ministry of Foreign Economic Relations and Trade, the Ministry of Commerce, and the Guangdong Provincial Economic Committee, the two companies have the right to purchase goods in China and directly purchase export-oriented goods at the Guangzhou Export Commodities Fair. The goods purchased by these companies in foreign markets are duty free.

Those belonging to the second category are united companies. They are mainly as follows:

A shipping company, which is formed jointly by the National Corporation of the Support Services for the South China Sea Oil Fields and the Guangdong Provincial Transportation Bureau. This company has cooperated with U.S., Singapore, Norwegian, Hong Kong, Japanese, and West German companies to form three off-shore shipping service companies in Zhongchang, Zhongxing, and Zhongji that are responsible for providing and transporting rigs. It is estimated that in the next 2 years, a total of 10 rigs will enter oil field areas. And if calculated on the basis of an average of 2 to 2.5 supply vessels serving each rig, the company would have to provide 20 to 30 vessels (with an average of 6,000 horsepower each).

A civil aviation aircraft company that is jointly set up with the Guangzhou Civil Aviation Bureau. This company so far has seven helicopters. But it does not have large and medium-size helicopters, and consequently it has cooperated with a U.S. air support service company and the Japanese Asahi Aviation and Shipping Company to lease helicopters. It has maintenance bases in Guangzhou and Zhanjiang. Its pilots have been trained in Japan, the United States, and France.

A meteorological service company that is formed jointly with the Guangzhou Central Meteorological Observatory. It has set up seven meteorological radars along the coasts of the South China Sea. The Guangzhou Central Meteorological Observatory has been accepted by the international meteorological organization and is one of the observatories that is releasing marine and other forecasts to the world everyday in English. It is also receiving forecasts from Beijing and Tokyo meteorological centers daily and it exchanges information with the Hong Kong Royal Observatory. The forecasts made by this company was once praised by a U.S. company.

A telecommunications company that is formed jointly with the Guangdong Provincial Telecommunications Bureau. It has cooperated with British Cable and Wireless to form the Huaying Telecommunications Service Company Limited. This joint venture has imported advanced telecommunications equipment worth more than 2 million yuan. The Guangzhou telecommunication center of this company has begun to provide service while a receiving and releasing station has been built in Shenzhen and will be included in the telecommunications service network in the near future.

A diving and vessel protection company that is formed jointly with the Guangzhou Salvage Bureau. This company has set up branches and built harbors and warehouses in Guangzhou, Zhanjiang, Shekou, Sanya, the North China Sea, and Shantou, forming a complete service network for the entire oil area in the South China Sea. But this company lacks experience in diving. Therefore, it has signed contracts with U.S., British, French, Norwegian, and Singapore companies to use foreign equipment and technicians for a while to provide diving services. The present 200 divers of this company are being trained by a U.S. company in groups.

There are also other subordinate companies and united companies, and some others are being formed.

The National Corporation of the Support Services for the South China Sea Oil Fields and its subsidiaries have taken various organizational forms, and this measure has to a certain extent broken away from the old stereotype of relying purely on administrative command, and also represents a bold trial in reforming the economic system.

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## OIL AND GAS

### COLLECTION, TRANSMISSION OF LOW-PRESSURE SICHUAN GAS DETAILED

Chengdu TIANRANQI GONGYE [NATURAL GAS INDUSTRY] in Chinese Vol 3, No 3, 28 Sep 83 pp 71-74

[Article by Cao Runcang [2580 3387 5547] of the Sichuan Petroleum Exploration and Planning and Design Academy]

[Text] As a result of fairly long-term exploitation, the gas fields in the Sichuan Basin which were opened quite early now have reduced output and lower wellhead pressures. The wellhead pressure in some gas wells is now lower than the pressure of the collection and transmission pipelines. This article will discuss technologies of collecting and transmitting low-pressure gas in gas fields.

#### I. Means of Increasing the Pressure of Low-Pressure Gas

1. The most common is installing a natural gas compressor station, a reliable and effective method. When there are still high-pressure gas wells in the gas fields and only a portion of the gas wells have wellhead pressures below collection and transmission pressures, installation of a compressor station may not be economically rational.
2. Selecting a gas jet to use high pressure for pressurization of low-pressure gas. This method requires less investment, is cheap to operate, maintains administrative simplicity, and conserves energy. This method was widely used in the United States, the Soviet Union, Romania and other countries in the early 1950's. Some countries still use multilevel gas injectors to pressurize low-pressure gas. The data indicate that jets can usually increase the pressure of low-pressure gas for 4-6 years.

#### II. Conditions for Using Gas Jets in Gas Fields

There are different techniques for using gas jets to increase pressure due to the differences between gas fields. The common ones are:

##### 1. Multilayer Exploitation of a Single Well

A gas well has low and high-pressure gas layers. Installing a gas jet when the well is exploited to make use of the energy from high-pressure layers to gather the low-pressure gas is an effective means of increasing pressure which permit drilling fewer wells and does not involve installation of additional pipelines.

## 2. Using High-Pressure Gas Wells To Carry Low-Pressure Gas

Collection and transport in the gas wells of Sichuan now mainly uses radial patterns (usually called multiwell gas collection). Within the same gas field, high and low-pressure gas with a great pressure difference often gathers at the same gas collection station. The low-pressure gas can be pressurized by passing high-pressure gas from nearby wells through a jet, which carries the low-pressure gas. Depending on the number of high and low-pressure gas wells, the pressure, the output and differences in conditions, one or more gas wells can be connected with a single high-pressure well or with multiple high-pressure wells.

In gas fields with branching collection and transmission, a gas injector can be installed at a downstream junction of the main pipe and the high-pressure gas from upstream can carry the low-pressure gas downstream.

## 3. Using High-Pressure Gas Fields To Carry Low-Pressure Gas Fields

The discovery of a new gas field means that new high-pressure gas wells will go into operation. Therefore, it is feasible to use the pressure from high-pressure gas fields to pressurize low pressure gas fields in the collection and transmission system.

## 4. Using Main Gas Transmission Line To Carry Low-Pressure Gas in Gas Fields

The main gas transmission line in Sichuan runs through the Wolonghe, Fujiamiao, Weiyuan, Zhongba and other gas fields, and the natural gas from the adjacent gas fields also enters the main line. The pipe diameter of the main gas transmission line is quite large and the gas feed is scattered. In summary, transmission pressure is too low. Therefore, there are favorable conditions for making full use of the large volume of gas being transmitted in the main line to exploit the potential of surplus pressure-bearing capacity in the main line. This is done through appropriate increases in transmission pressure in the main gas transmission line and installation of a gas jet in the main line to bring the low-pressure gas into the main gas transmission line or mix it into a nearby pipe network.

## III. Problems of Increasing the Pressure of Low-Pressure Gas in Some of Sichuan's Gas Fields

### 1. The Weiyuan Gas Field

Collection and transmission flow in the Weiyuan Gas Field is accomplished with a normal atmospheric temperature separation radial system, with a limited number of marginal gas wells that use branching collection and transmission flows. There are now some gas wells with a wellhead pressure under  $40 \text{ kg/cm}^2$ . It will not be possible to maintain continuous exploitation unless measures to increase pressure are adopted. Because the period in operation and gas extraction situation is different for each gas well, however, a portion of the gas wells have relatively high pressures. Each of them is mixed with low-pressure gas in a gas collection station.

Based on the situation of progressively decreasing gas well pressures in the Weiyuan Gas Field, it is estimated that the gas wells which now have a wellhead pressure of more than 80 kg/cm<sup>2</sup> can continue to be higher than the gas transportation pressure for several years, and new wells will continue to go into production in the future. There is a potential, therefore, for using high-pressure gas to increase the pressure of low-pressure gas. This gas field is currently using two domestically produced gasoline engine compressors to increase the pressure of low-pressure gas (1 compressor in operation, 1 in standby). This requires a large investment, consumes a lot of gas itself, and has high administrative costs. Energy consumption and various expenses will continue to grow as the amount of low-pressure gas in the gas field increases. It can be seen from this that it would be best if the Weiyuan Gas Field begins using gas injectors to increase the pressure of low-pressure gas within the next few years.

## 2. The Xinglongchang Gas Field

The wellhead pressure of current producing gas wells in the Xinglongchang Gas Field is universally low. According to forecasts and distributions for the Xinglongchang Gas Field, apart from the gas supplied to Zugong City, the surplus gas is connected with the Luzhou-Weiyuan pipeline for transport to Chengdu and elsewhere. Even though there is already pressurization with a compressor, the low pressure of the gas field still makes it possible to install a gas jet and use the high-pressure gas wells at the Guanyinchang Gas Field to pressurize the low-pressure gas from the Xinglongchang Gas Field and transport it into the Luzhou-Weiyuan pipeline.

## 3. The Changyuanba Structural Zone Gas Field

The gas field in the Changyuanba Structural Zone has been exploited for a fairly long time. Currently, some of the gas wells have already entered the stage of low-pressure gas production. The nearby factories use a large amount of gas, so it is transmitted into a local low-pressure pipe network.

We should consider the following means for exploitation of the surplus natural gas in an economically effective way:

- 1) For the low-pressure gas which cannot be put into the main gas transmission pipeline, any of the following can be adopted after examining the specific conditions: it can be transmitted to the Fuchang and Changna low-pressure pipelines for supply to local users; areas near the main gas transmission line can use the surplus pressure-bearing capacity of the main line (under design conditions, to increase transmission pressure), and increasing the pressure through a gas jet, and connect it with the main lines or the Changfu and Changna lines.

- 2) Make the greatest possible use of high-pressure gas in the upper part of the gas field and the transmission pressure of the main collection and transmission pipeline in combination to carry the low-pressure gas, and postpone the construction of compressor stations.

3) When the upper compressor station is needed, consideration should be given to conserving power by making great efforts to pressurize the low-pressure gas into the Fuchang and Changna low-pressure pipeline and reduce the power consumption of the compressor.

#### IV. Reduction of Pressure Losses in Collection and Transmission

Increased pressure losses in natural gas that is collected and transmitted at high pressures seldom attracts attention. In terms of the collection and transmission of low-pressure gas, however, an increase in any type of pressure loss can directly produce major effects. We should, therefore, adopt measures to make the greatest efforts to reduce all types of pressure losses during the process of collecting and transmitting low-pressure gas.

##### 1. The Well Station System

When gas wells begin low-pressure exploitation, the equipment in well stations such as throttle valves, heat exchangers, water jacket heaters, etc., should be dismantled to reduce pressure losses.

##### 2. Collection and Transmission Flows

There are many radial collection and transmission flows in a gas field. Pipeline pressure losses are quite substantial if the gas and water mixture is transmitted through the branch gas collection line when there are great distances or differences in elevation between the wellhead and the gas collection station. To overcome this, whenever the wellhead and main collection and transmission pipeline are close, there can be a changeover to branch flows. Branch gas collection lines which have a great difference in elevation can be changed to single-well field separators to transmit the gas and water separately and reduce pressure losses in the collection and transmission pipeline.

As for collection and transmission flows of low-pressure gas in gas fields, consideration must be given to the current conditions of collection and transmission pipelines, such as gas well output, forecast data on pressure and water yield, dealing with water in gas fields, installation of compressor stations, production management, and other factors. There should be comprehensive control and economic comparisons to determine transformation programs for each well.

##### 3. The Cleaning of Collection and Transmission Pipelines

Pipeline cleaning is a familiar process in main gas transmission pipelines. As a result of restricted equipment manufacturing and other reasons, this type of work has not yet become universal. We should now adopt measures to reduce pressure losses in collection and transmission pipelines.

1) Cleaning the main pipeline. The Changna gas transmission pipeline went into operation in 1964 and the Fuchang line went into operation in 1965. To this day, neither of them has had the facilities for pipe cleaning. Because they pass over mountains and hills, there is severe accumulation of liquid and particulate matter, which leads to major pressure losses in the pipes. On-the-spot testing



at the No 1 well on the Fuchang line showed gas transmission pressure losses more than 2 times greater than calculated. The reduction of pressure in this gas field in recent years has required the building of a compressor station at the gas field. If the pressure in the gas collection line falls even more, the compression ratio of the compressors must also be raised. Calculated in terms of compressor power, 5 to 20 percent more compressor power is consumed in uncleaned lines compared to cleaned lines. It can be seen that main collection and transmission lines must not only have pipe cleaning facilities, but also that pipe cleaning operations should become a normal procedure in production.

## 2) Cleaning Branch Pipelines

After production for a period of time, branch gas collection lines which transmit a gas-water mixture over a long distance or substantial differences in elevation will also have a problem of sudden increases in pipeline pressure losses. Between the Weiyuan No 39 Well and the No 23 Well gas collection stations, for example, there is an elevation difference of 175 meters. The actual pressure loss in the pipe is 10 times greater than the calculated pressure loss. Cleaning should also be done on this type of pipeline.

The branch gas collection pipes in gas fields have small diameters, are numerous and cover short distances. Most have diameters of 89 to 159 mm and require quite a bit of cleaning. For this reason, mobile pipe cleaning equipment for cleaning the branch gas collection lines may be adopted. By preinstalling a joint at each end of the branch line, they can assemble some mobile equipment for pipe cleaning and send it to the site for assembly and use. One set of pipe cleaning equipment can be used for many pipes, which conserves investment and increases the utilization rate.

## 4. Reducing Pressure Losses at Stations on Main Gas Transmission Lines

Natural gas is transmitted from eastern Sichuan to the Chengdu area through almost 1,000 kilometers of main gas transmission pipelines. It passes through dozens of main lines and separation measurement stations, more than 10 of them being large stations. On-site tests of total gas and separation measurement at the Fujiamiao station show that pressure loss in the station is greater than  $1 \text{ kg/cm}^2$ . It is obvious that total pressure loss for all the large-scale stations in the pipeline could be quite substantial. Because of the excessive pressure losses in the station, the natural gas which is transmitted from eastern to western Sichuan originally could make use of the excess pressure-bearing capacity of the main pipeline to carry low-pressure gas as it passed through low-pressure gas fields (or low-pressure wells), but all the pressure is being consumed by so many stations. This means that in low-pressure gas fields a compressor station must be built beforehand or the power consumption in the compressors must be increased. We should, therefore, make great efforts to change full gas flow separation measurement stations to branch line separation stations. Future station construction should also be done this way. This can reduce equipment, investment, and land, and can also reduce pressure losses in the stations.

In summary, pressure losses in the collection and transmission system cannot be ignored. Whenever the conditions permit, there should be great efforts to adopt various measures for reducing pressure losses in the system.

#### V. Compressor Selection

Wellhead gas pressures decrease as gas fields are exploited until the stage where it is useless to use gas jets to increase pressure. Thus, the final technical measure for exploiting low-pressure gas is pressurization with compressors.

Most of the gas fields in Sichuan are in mountainous and hilly areas that have inadequate water and electricity. Great efforts should be made during selection of suitable units to avoid installing complex systems linked to outside water and electricity supplies. Thus, selection of small mobile compressor units is most suitable.

Wellhead pressure in some gas wells is so low now that piston-style compressors cannot be used. We should begin trial manufacture of vacuum extraction compressors. When wellhead pressure is below  $0.07 \text{ kg/cm}^2$  they can permit continued extraction and raise the collection rate of residual gas.

#### VI. Conclusion

1. Although gas injectors are now widely used abroad, this line of work has just begun in Sichuan's gas fields.\* We must quickly and earnestly summarize and extend this technology.

2. Utilizing high-pressure gas with gas jets to pressurize low-pressure gas is easy in a single gas well or within nearby gas wells. The question of how to utilize high-pressure gas in the main gas transport lines with gas jets to pressurize the low-pressure gas in gas fields is a problem which awaits a solution. For this reason, low-pressure gas collection and transmission should look at the overall situation and give comprehensive consideration to the extraction, transmission and distribution processes.

\*See TIANRANQI GONGYE Vol 3 No 2

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STRUCTURAL BELTS, DISTRIBUTION OF OIL, GAS FIELDS IN SONGLIAO BASIN DESCRIBED

Beijing SHIYOU SHIBAO [ACTA PETROLEI SINICA] in Chinese No 2, Apr 83 pp 1-8

[Article by Yang Zuxu [2799 4371 1645], Long Xingren [7893 2450 9988], Chen Fengzhi [7115 7364 3069], and Cui Xuezhou [1508 1331 0719], Jilin Oilfield: "Structural Zones and Distribution of Oil and Gas Fields in the Songliao Basin"]

[Text] ABSTRACT. The Songliao Basin is divided into four first-order structural belts in terms of deposition and structural evolution in the course of its formation and development: the main faulted-downwarped-folded belt in the west, the central faulted-upwarped-folded belt, the eastern secondary faulted-downwarped-folded belt, and the marginal overlap fold belt. The first three are the main components of the basin. Local structures fall into three annular zones: the zone of pools with lithologic traps (central zone), the zone of pools with structural traps (intermediate zones), and the zone of scattered pools (outer zone). The exploration prospects of each zone are described and preliminary approaches to prospecting in deep-lying strata are outlined.

I. Structural Belts of the Songliao Basin

A. Main Developmental Characteristics of the Songliao Basin. The Songliao Basin is bordered by the Variscian Xing'an folding system of Inner Mongolia, the Variscian fold system of Jilin and Heilongjiang, and the geographic axis of Inner Mongolia; it has a total area of about 260,000 square kilometers. In recent years, drillhole data have proved that no "central craton" is present in the basin, but that its basement consists primarily of Carboniferous-Permian and Silurian-Devonian metamorphic rock and granite. The metamorphic rock was produced by contraction and recovery of the Central Asian Trench between the Siberian and Sino-Korean plates during the Paleozoic and is a continental extension of these two plates into the Central Asian Trench during the Paleozoic. The crustal structure of the basin shows evident mirror imaging: the area of the basin in which the Mesozoic and Cenozoic sediments are thickest is also the belt in which the Mohorovicic surface swells upwards to the greatest height. The crust is 29 km thick in the central part of the basin, about 37 km thick at Daxing'an Peak on its western edge, and about 34 km thick at Zhangguangtai Peak on its eastern edge. The swell in the Mohorovicic surface has the same north-northeastward orientation as the basin itself.

At the beginning of the Triassic period, eastern China entered a new developmental stage. The Triassic and middle and lower Jurassic systems are mostly lacking in the basin, having undergone uplifting and denudation.

The period between the late Jurassic and early Cretaceous, in which the Dengloulou formation and the first and second members of the Quantou formation were deposited, was the early period of the basin's development. As a result of tensile stress, the crust underwent fracturing accompanied by magma activity, producing a rapid-infilling type of rift sediments. Current seismological results indicate that the basin is underlain by more than 10 Jurassic fault depressions, with a total area of about 30,000 km<sup>2</sup>, trending northeast or north-northeast. The Dehui Jurassic fault depression has an area of about 3,800 km<sup>2</sup>; in it, the upper Jurassic series is about 2,000 m thick and consists of infilling-type clastic material which contains coal, oil or gas. Its upper and lower sections contain volcanic rock and pyroclastics. The Dengloulou period continued the north-northeastward lineaments of the upper Jurassic; sedimentation, against a background of deep fault activity, covered an area of about 55,000 km<sup>2</sup>, forming the embryo of the basin. The basic structural outline consists of "two grabens and one horst," i.e., (1) the secondary rift belt in the east, in the zone from Suihua and Sanzhao to Wangfu, in which dark purpleish-gray clastics were laid down to a depth of 1,500 m, and where the oil and gas generation conditions are poor; (2) the main rift belt in the west, controlled by deep faults running 400 km from Keshan in the north to Changling in the south, which is 80-100 km wide and has a maximum thickness of 35 km at its sedimentation center, in the zone from Xinli west to Gulong; it contains primarily compensation-type sediments with many intercalations of dark mudstone, it is thought that conditions for oil generation are present near its deposition center; and (3) the central fault depression, located between the two grabens in the Diaoyutai-Denglouku-Toutai-Qinggang belt and consisting of a saddle structure which is high in the north and south and low in the center; the Dengloulou sediments are about 500 m thick in the area of the saddle and join the grabens on its east and west into a single area. The period during which the first and second members of the Quantou formation were laid down continued the pattern of two grabens and one horst, with two sedimentation centers, east and west, and an expansion of the deposition area to nearly 100,000 km<sup>2</sup>, forming a single lake basin. This basin was transitional between the fault depression and downwarp stages; its sediments consist of 600-1000 m of red gravel and mudstone which lack the conditions for oil generation.

The period in which the third and fourth members of the early Cretaceous Shiquan formation, the Qingshankou formation, the Yaojiakou formation and the Nenjiang formation of downwarp sediments were deposited was the main period of deposition in the basin, with its area extending in successive advances to the entire basin area of 260,000 km<sup>2</sup> and comprising a total sediment volume of about 190,000 km<sup>3</sup>, or approximately 56 percent of the total volume of sedimentary rock present. The sediments overlap in large areas toward the perimeter, particularly to the west. During the downwarp deposition period, the lake basin experienced two advances and two retreats. The two advances were transgressive periods, represented by the first member of the Qingshankou formation (about 100 million years ago) and the first member of the Nenjiang

formation (about 75 million years ago), in which there was intense deposition of a large area of deep gray to black mudstone oil parent rock, while the two retreats were periods when the lake waters receded and the Yaojiang formation and the middle and upper Nenjiang formations, consisting of red and gray-green to gray sand and mudstone which make excellent reservoir strata, were deposited. During the dowarp sedimentation period, the basin showed clear-cut annular facies zones on the macroscopic scale, in which two sequences of oil-producing rock were sandwiched vertically between three layers of reservoir rock, namely the upper Quantou formation, the Yaojia formation, and the middle and upper Nenjiang formation, forming an excellent oil matrix-reservoir-cap rock combination. The early fault-depression sedimentation took place against a background of prolonged growth fault activity, while the downwarp sedimentation period took place in the context of subsidence of the entire basin over a large area. But the earlier fault depression sediments are thick, indicating that the deeper parts of the faults continued to be active, although this was not clearly apparently above the faults, showing up only in the form of the downwarping folds. Thus the earlier two grabens and one horst were transformed during the downwarping period into two downwarps and one upwarp, which became bordered by a large area of draping sediments, primarily of the overstepping type. Anomalous activity was also present in the downwarp stage; for example, the central fault-upwarp belt in the Sanzhao area ceased its growth fault activity and subsided as a whole, forming a broad, deep downwarp in the northern area, which had a major effect on the formation on the Daqing oilfield.

The basin contracted between the late Cretaceous and Tertiary. In much of the area the folds were uplifted and denuded, so that only the western area received some coarse clastic sediment, about 500-1000 m thick so that the sediments from the downwarp period became more deeply buried there and the oil generating rock reached the maturation threshold depth. In addition, starting with the early Cretaceous sedimentation there were two structural movements which produced a large number of structures that were decisive in the formation of the oil and gas fields.

**B. Force Analysis.** In the early period ( $J_3-K_1$ ) the basin experienced primarily vertical movements and the crust was controlled by tensile (or tensile-torsional) stresses, while in the later period ( $K_2$ ) it was controlled by compressional (or compressional-torsional) stresses, and horizontal movements predominated.

The change in dynamics was related to plate movements. The tensile stresses in the early period resulted from collision of the Kra-Pacific Plate with the Asian continent, resulting in heating, swelling and tension cracking of the mantle, followed by cooling, contraction and subsidence; in the later period the stresses resulted from relative compression, produced by a widening of the Sea of Japan during the early Cretaceous which accelerated during the Tertiary. The eastern edge of the basin is located on the Yilan-Yitong graben, whose evident spreading during the late Cretaceous and Tertiary unquestionably produced compression of the basin. The compressive force from the east first produced folding the uplifting of the eastern part of the basin, while the western part was subject to late Cretaceous-Tertiary compensatory

deposition. The southeastern part of the basin underwent the strongest folding, which gradually weakened toward the west. This fact also reflects the east-to-west direction of the compressive force. The compressive stress made the basin contract, with folding and uplifting, producing successive anticlinal, synclinal and anticlinal sections largely parallel to the axis of the basin; the strata were subject to a relative tensile stress, generally producing a series of normal faults with different displacements.

The change from one dynamic situation to the other began before the K<sub>2</sub> sedimentation, as indicated by the fact that the two compressive movements, before and after the late Cretaceous sedimentations, formed two sets of compression structures. One example of the change in the stress situation is the Gudian fault, which is a normal fault below and reverse fault above as a result of having been subject to two stages of activity of opposite types: in the early period the fault's eastern wall sank, forming the old upwarp to the west which is associated with the growth fault; the east-to-west compressive force before the late Cretaceous sedimentation made this fault overthrust westward, so that a compression anticline was formed in the shallow area to the east of the fault. A second example is the Honggang and Da'an faults, both of which are normal below and reverse above. Their circumstances were similar to that of Gudian: earlier normal faults resulting from tensile stress, compressive activity at the end of the late Cretaceous sedimentation, with activity in the opposite direction along the older fault plane, forming a reverse overthrust fault and compressive structures.

C. Structural Belts. Based on the structure of the basin and the discovery of the three periods, involving faulting, downwarping and folding, the basin can be divided into four belts:

- (1) the main fault, downwarp and folding belt (western belt);
- (2) the central fault, upwarp and folding belt;
- (3) the eastern secondary fault, downwarp and folding belt;
- (4) the overlap fold belt along the edge (marginal belt).

The first three are the main components of the basin, while the marginal belt is of secondary importance.

D. Local Structure Types. Local structures fall into three classes: upwarp-tension structures associated with upwarping movements, compression structures associated with horizontal compression, and complex structures produced by successive tension and compression.

1. Upwarp-tension structures. Four Jurassic structures have been provisionally identified in the Dehui depression. They are overlain, with angular unconformity, by a structureless Cretaceous series.

Structures formed between the Dengloulou and Quantou periods are of several types. First, structures formed by thinning out of sediments on the upthrown walls of growth faults which originated during this period. These structures show swelling of the basement, while the first and second members of the Quantou formation as well as the Dengloulou formation thin out. Examples include

the upwarped deep-lying Da'an-Haituozi strata on the eastern side of the Da'an fault, and the structures at the west side of the Gudian fault. These deep structures have thus far been little studied. Another type consists of structures associated with the downthrown sides of growth faults, very few of which have been discovered to date. A Third type is structures associated with later faulting, such as the situation in which the standard  $T_1$  stratigraphic sequence is structureless, while certain standard strata below  $T_1$  contain structures, largely consisting of fault noses or incomplete anticlinal structures.

2. Compression structures. These are the main structures in the Songliao basin and can be divided into two categories in terms of their times of formation.

First Category. Structures which developed in the Early Cretaceous and were subjected to stronger compression in the late Cretaceous. These are called twice-compressed structures. Their intermediate strata ( $T_1$  and  $T_2$ ) show structures of large amplitude while in the layers above and below ( $T_3$  and  $T_4$ ) [as published] the amplitudes are smaller; the structures are largely in the form of belts, and are largely anticlinal.

Second Category. Singly-compressed structures formed in the late Cretaceous, whose structures are of greater amplitude in the higher-lying than in the lower-lying strata and are primarily anticlinal and belt-like.

Because considerable numbers of local structures developed in the basin during these two periods of compression, the principal structures can be divided into four rows from east to west: the Qingkou-Nong'an structural belt, the Changchunling-Denglouku structural belt, the Daqing-Heidimiao structural belt, and the Keshan-Honggangzi structural belt. The eastern three belts are twice-compressed structures, while the westernmost is a singly-compressed structure; there are also some scattered structures between these belts. These are compression structures; the compressive force was applied from the east of the basin, as indicated by the fact that the intensity of folding in the basin is greater in the east than in the west, that the dip of the strata is greater in the east, that anticlinal structures are largely parallel to the long axis of the basin, with a north-northeastward (or northeastward) linear arrangement, that some major structures like the Daqing Rampart and the Denglouku structure show a gentler slope on the eastern flank than on the western flank, and that many structures have decreased amplitude or even fade out in the deeper layers ( $T_2$  and below). These facts indicate that the structures were formed by horizontal compressive (or compressive-torsional) stress resulting in slippage between strata.

During the contraction of the basin, an enclosing pressure must have developed around the periphery of the basin; as a result, the orientations of some structures disagree with the main structural belts. In particular, the formation of some structural noses may have resulted from anomalous uplifting of certain structures in the basin relative to others, owing to circumferential and horizontal compression.

3. Complex structures. These structures are numerous in the central faulting-upwarp-folding belt. In them the basement swells and is uplifted, forming upwarp-tension structures, which were clearly altered by subsequent horizontal compression. This is also a structural sign of the transition between the two types of stress. Relatively typical structures of this type include the Fuyu No 3, Dasanjigzi, Nong'anxi, Diaoyutai, Yangdachengzi and Denglouku structures. In the Fuyu No 3 structure, for example, the basement and early structures swell upwards somewhat westward of the present structures, and the effects of the two periods of compression, before and after the late Cretaceous, are evident: the structures to the east are raised, tilted and shifted, while their amplitudes are decreased.

## II. Distribution of Oil and Gas in the Songliao Basin

A. Relationship Between High Subsurface Temperature and Oil-Gas Distribution in the Basin. The average geothermal flux in the basin is 1.7 microcalories/cm<sup>2</sup>-sec, and the average temperature gradient is 3.6°C/100 m, while the average gradient in the main body of the basin (central, eastern and western belts) is 4.2°C/100 m, close to that in the Los Angeles basin on the West Coast of the United States. The threshold burial depth required for organic material in the rock to be converted to hydrocarbons depends on the temperature gradient and the stratigraphic period. In the basins of East China the depth is generally 2,200-2,500 m, but the initial maturation threshold in the Songliao Basin is 1,200 m, equivalent to a subsurface temperature of 68°C. At 1,200-1,900 m the temperature ranges from 68° to 90°C and heavy oil predominates among the hydrocarbons; between 1,900 and 2,900 m the temperature ranges from 90° to 120° and light oil predominates; below 2,900 m the temperature exceeds 120°C, the reflection rate exceeds 2.0 percent, and the hydrocarbons undergo thermolysis, largely producing dry gas. As these data indicate, the oil parent rock in the basin has shallow maturation depths (beginning at 1,200 m) and the oil formation area is narrow.

1. The main oil parent rock, i.e., the lower Cretaceous Qing'ankou formation and lower Nunjiangkou, is buried at depths between 1,000 and 2,300 m in the Sanzhao area of the western belt, an area of extensive oil generation. The high subsurface temperature and shallow oil generation threshold are important conditions for the formation of a series of medium-depth and shallow oilfields at Daqing, Fuyu and elsewhere.

2. The Jurassic and lower Cretaceous Denglouku formation, which is the secondary oil or gas generation rock and target stratum of the basin, is generally buried at 2,500 m or below in the western belt, and primarily gas is sought in it.

The abovementioned two factors dictate that the upper downwarp structures of the Songliao Basin contain primarily oil, while the lower fault structures contain primarily gas; in other words, searching primarily for gas (including light oil) in the intermediate and shallow layers is the proper approach for future oil-gas prospecting in the basin.



3. Distribution of Intermediate- and Shallow-Depth Oil and Gas in the Basin. The intermediate- and shallow-depth oil strata are primarily five pay sequences whose source rock is the Qingshankou Nenjiang formations: the Heidimiao stratum, the Saertu stratum, the Putaohua stratum, the Gaotaizi stratum and the Fuyu stratum (including the Yangdachengzi stratum). These are the principal oil strata of the basin, and the distribution of oil pools in them is determined by structural and depositional factors. The latter include the following. The medium-depth and shallow strata are downwarp sediments, but the thickness of the sediments and the location of the deep downwarp are closely related to the deep-lying fault, whose direction controlled the sources of material and the direction of the main water systems. Over a long period, two main water systems, one northern and one southern, developed on the long axis of the basin, producing the Keshan-Xingshugang sandstone body running from north to south and the Baokang-Qian'an sandstone body running from south to north, and creating the most favorable oil generation region in the bend of the Song and Nen Rivers. In addition there are certain secondary sedimentation systems which give the Hongliao basin a pronounced annular arrangement of sedimentary facies zones. As to structural conditions, two periods of compressive movement of the intermediate and shallow strata prior to and following the late Cretaceous produced a large number of structures, creating excellent trap conditions.

Based on the sedimentation and structural conditions, the authors believe that the main picture of oil pool distribution in the five pay series is that pools with structural traps predominate, and oil pools are arranged in three concentric annular regions.

1. The Zone of Structural Traps (Intermediate Zone). This zone has all of the conditions for generation and accumulation of oil and in addition has a large number of anticlinal structures and fault-nose structures, so that the conditions for generation, accumulation, capping and trapping all occur together. The main oil or gas fields that have been discovered to date are almost all in this zone which accounts for about 98 percent of proven reserves. The zone has an area of about 19,000 km<sup>2</sup>; it is of annular shape and includes the Sa'ertu, Lamadiazi and Xingshugang structures of the Daqing Rampart, as well as the Shengping structure, the Fuyu 1 and 2 structures, the Motou structure, the Gudian structure, the Datuozi structure, the Qingzinjing structure, the Honggangzi structure, the Yingtai structure and the Longhuptao structure. Most of the oilfields found in this zone are of the structural-trap type; those with lithologic traps occupy a highly subordinated position.

2. The Zone of Lithologic-Trap Pools (Central Zone). This zone occupies somewhat more than 10,000 km<sup>2</sup> inside the structural-trap zone. It is near the optimal oil generation center, with abundant oil sources; the reservoir sandstone is generally continuous and has certain of the necessary structural characteristics. There are three main types of lithologic-trap oil fields. The first is structural-lithologic trap oilfields, such as the Qian'an, Xinli, Putaohua and Aobaota structures. The second comprises lenticular sandstone reservoirs, wedging out of upward-sloping reservoirs, and reservoirs controlled by both fault noses and lithologic traps. In the Sanzhao, Gulong,

Xinbei and Da'an areas, the oil-containing bodies are of these types. A third type is oil in fissured mudstone largely in the central oil generation zone where there is very little sandstone, and fissures in mudstone and sandstone strata no thicker than 0.2-0.4 m provide the only reservoir spaces. The oil content is inconsistent areally; traps in fissured mudstones have been found in the Yaojia and Qingshankou formations in the Da'an and Xinbei areas.

3. The Zone of Scattered Oilfields (Outer Zone). This is an extensive zone located outside the structural-trap zone and generally contains large amounts of reservoic sandstone, while the oil generation and hydrologic conditions are poor; however, there is some potential for traps. Some oil or gas showings have already been discovered, such as the Heidimiao, Shuangtuozi and Taikand oil or gas wells. The oilfields have structural or lithologic-stratigraphic traps, but are few and scattered.

These three zones are parts of a single contour, which may reflect the basic oil pool distribution characteristics; because there are five pay series in the vertical direction which differ somewhat in their distribution, there may be some overlap in plan, but this should not prevent us from understanding the distribution of the main oil and gas fields. Recognizing the three large zones can give an overall conception of the distribution of pools in medium-depth and shallow-lying oil strata in the basin, namely that the innermost zone has primarily lithologic traps, the middle zone primarily structural traps, and the outer zone primarily medium and small scattered oil and gas fields. The arrangements of oilfields in the individual oil strata varies and must be studied individually.

The authors believe that there is considerable potential for lithologic-trap oilfields in the inner zone. Further exploration of oil strata at medium and shallow depths, would be realistic, but the oil-bearing strata are highly variable and consist primarily of thin strata with medium to low yields. The main oilfields in the intermediate zone have already been discovered, but some structures have not yet been fully explored and some structural-trap oil pools of secondary importance may be discovered; these are the principal kind of pools in this zone, but there are also some lithologic-trap pools. The outer belt is of least importance, because the pools are small and scattered and the reserves are not concentrated; thus future exploration should focus primarily on the two inner zones, while conscientious research should be conducted in the outer zone and a few particularly promising areas should be chosen for exploration.

C. Problems in Exploring the Deep Strata of the Songliao Basin. The deep strata in the fault depression structure, from the second member of the Quantou formation down, have been little explored thus far, and we can offer only a few opinions of a general nature. In recent years commercial gas flows have been found in the middle and lower Quantou formation in the Dehui depression, with Jurassic source rock. The oil and gas showings in the Quantou formation within the Yangdachengzi structure may also have originated in Jurassic rock. About 300 m of dark-colored Jurassic limestone has been encountered in drilling at Nong'an. These data indicate that the Jurassic series is capable of generating oil. The problem is that the Jurassic facies change rapidly, and areally

they primarily constitute a coal-forming environment. The distribution of oil generating rock may be extremely limited. But natural gas may be formed during the coalification process; many gas fields worldwide have developed in coal measures, thus the Jurassic sequence may be viewed as oil and gas parent rock, particularly gas parent rock. The Jurassic fault-depression sediments in the basin cover an area of about 30,000 km<sup>2</sup> and range in thickness from about 200 to 2,000 m, so that they are worth serious attention.

The Dengloulou formation, 1,000 to 3,500 m thick and covering an area of about 50,000 km<sup>2</sup>, is a relatively large area. In recent years, exploratory wells have been drilled in the Sanzhao area, in the Daqing rampart and in the Fuyu No 3 structure, and gas showings and commercial gas flows have been found at the top of the basement in the Dengloulou formation. The gas may have come from the Jurassic sequence or the Dengloulou formation itself. Oil and gas showings have been found in the second member of the Quantou formation within the Shuangtuozi structure, and it is theorized that they are associated with deep-lying strata. From the central fault-upwarp-fold belt east, the Dengloulou formation is 1,500 m thick or less and its oil generation conditions are poor, but very little drilling has been done thus far in the main downwarp-folding belt in the west, and although dark-colored mudstone has been found, oil signs have been poor. Based on the knowledge that the direction of the fault depression controls the main drainage systems, it is hypothesized that the center of sedimentation is in a strip west of Gulong, Da'an and Xinli, that the Dengloulou formation may be as thick as 3,500 m, and that it may have the conditions for generation of oil.

The future approaches to exploration of deep-lying strata are as follows.

(1) The objective in the Jurassic sequence will be light oil and gas. Starting with the Dehui downwarp, a comprehensive evaluation will be made on the basis of seismic studies and parametric wells with the primary aim of locating traps for Jurassic oil pools and secondary pools. (2) In the central fault-upwarp-folded belt, the Jurassic sequence is essentially missing in areas distant from the Dengloulou sedimentation center, and gas generation conditions are poor, so that exploration will proceed only slowly for the present. (3) In the main fault-downwarp-folded belt in the west, with a primary focus on deep-lying gas fields, we will carry out seismic-facies studies and evaluations based on a combination of seismic and parametric well data in order to identify deep faults and structures, then drill parametric wells in the vicinity of the sedimentation centers, e.g. east of Da'an (the Da'an-Haituozi deep upwarp), to explore buried ancient mountains and deep-lying strata.

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8480

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## OIL AND GAS

DAQING OUTPUT SEEN STABLE AT 50 MILLION TONS A YEAR THROUGH 1990

Beijing RENMIN RIBAO in Chinese 17 Dec 83 p 3

[Article by reporter Shao Lei [6730 7191]: "Stable Production of Oil at Daqing Relies on Scientific and Technological Progress"]

[Excerpts] Some good news was reported at the Sixth National People's Congress: The annual production of 50 million tons of petroleum by the Daqing Oil Fields will be stable to 1990. This news excited people and also caused them to wonder: Is there any scientific evidence for stable production at Daqing? For this reason, we visited China's famous oil recovery expert Li Yugeng [2621 5713 1649].

The head of the Daqing Oil Management Bureau, Li Yugeng is one of the developers of the Daqing Oil Field. Oil field exploration, drilling, and recovery--he's done them all.

The 54-year-old Li Yugeng told us straight to the point that the fact that people are concerned about stable production at the Daqing Oil field inspires every worker and technician there. There is ample scientific evidence for saying that there will be steady production at the Daqing Oil Field until 1990. At the end of 1981 we began to survey the actual situation and developed a stable production plan. Verification from the perspectives of resources, engineering, and economics, shows that resource conditions exist and Daqing is currently only recovering 50 percent of its recoverable reserves. The potential for technological reform, management and administration, and economic results is very great and prospects are very bright.

"On the other hand, we have not ignored the difficulties that exist." Li Yugeng then briefed us on some conditions at the oil field. He said that every ton of crude oil recovered now costs several times what it did when the field was first developed. The overall water content in the oil field is already over 65 percent, and the underground distribution of oil and water is very complex. As the production of the oil field naturally declines, maintaining an annual production level of 50 million tons of oil is a very big job. Take new wells, for example. Before 1980 fewer than 400 wells were drilled annually, but this year 1,000 wells will be drilled, and in 1984 it will be even higher. It is estimated that between 1981 and 1987 a total of

7,000-8,000 wells will be drilled, equivalent to the volume of work of the previous 20 years. In addition, a great many gushers turn into pump wells and electric pump wells, and much surface piping design and surface construction work will correspondingly increase because of this. Interspersing of oil layers and water layers creates certain difficulties for drilling, well cementation, and perforation.

At this point, Li Yugeng stood up and said, "Daqing people have never bowed their heads before difficulties. On what should we rely to overcome these new difficulties and new challenges we face in the eighties? On revolutionary spirit and a scientific attitude. We should stress scientific and technological progress while developing the tradition of dedicated struggle." Li Yugeng told us about a series of technological measures developed by scientific and technological personnel at Daqing to guarantee stable production, including drilling adjustment wells to develop oil-poor layers in existing oil fields, turning gushers into pump wells, comprehensive adjustment and surface transformation based mainly on water injection, and developing new oil fields. Arrangements have also been made to deal with the questions of adopting a variety of ways to improve the quality of enterprise technical ranks and there have already been some initial results. For example, when drilling an adjustment well in a developed oil field, the problems of discriminating high pressure water layers and removing blockages from some low pressure oil layers have already been tentatively solved. Specialists in various fields and production personnel will still undergo technical training in rotation by groups and by periods.

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CSO: 4013/74

## OIL AND GAS

### BRIEFS

RECORD JANUARY OUTPUT--Beijing, 9 Feb (XINHUA)--China pumped 9,333,000 tons of crude oil in January, a 5.5 percent increase over January 1983, the Chinese Ministry of Petroleum Industry said here today. This figure is 8.6 percent of the country's annual target, which is 108 million tons. The 1983 output was 106 million tons. Average daily output in January this year was 301,000 tons, hitting an all-time high. Daqing and Shengli, China's first and second largest oil producers, as well as the Liaohe and Zhongyuan oilfields, all reported record output for the first month of the year. Daqing in Heilongjiang Province topped the state production quota set for January by 74,000 tons. Shengli in Shandong Province pumped 1.7 million tons in January, also a record high. Zhongyuan, a new oilfield still being developed in Henan Province, is now producing 10,000 tons of oil a day. Four oilfields have been built in the 5,300-square-kilometer Zhongyuan oil zone since 1979 when development started. Now more than 500 producing wells are in operation, producing over 3 million tons of oil in 1983. [Excerpts] [OW100551 Beijing XINHUA in English 1138 GMT 9 Feb 84 OW]

MORE RESERVES VERIFIED--Beijing, 20 January (XINHUA)--China verified more than 500 million tons of oil reserves last year, the Ministry of Petroleum Industry announced today. The discoveries were largest after the Daqing oil field in Heilongjiang Province and the Renqiu oil field in Hebei Province, a ministry spokesman said. The new reserves were found in old oil fields, including Daqing, Liaohe in Liaoning Province, Dagang in Hebei Province, Shengli in Shandong Province, and Zhongyuan in Henan Province, or in their adjacent areas. China produced 105.985 million tons of crude oil in 1983, up 3.8 percent over 1982. [Text] [OW201753 Beijing XINHUA in English 1441 GMT 20 Jan 84]

CSO: 4010/43

## NUCLEAR POWER

### FRENCH EXPERIENCE PROVIDES MODEL FOR NUCLEAR POWER DEVELOPMENT

Shanghai DONGLI GONGCHENG [POWER ENGINEERING] in Chinese No 6, 15 Dec 83  
pp 1-3

[Article by Huang Yicheng [7806 3015 6134]]

[Excerpt] 3. Some Suggestions For Speeding Up the Pace of Nuclear Power Plant Construction in China

1. Conditions in China require that the construction of nuclear power plants be accelerated; this will require hard work, but it can be achieved.

The distribution of China's energy and natural resources corresponds poorly with the distribution of China's industry. If we limit ourselves to conventional energy sources it will be necessary to haul coal and transmit electrical power over long distances, which presents both technical and economic difficulties. For this reason, long-term considerations indicate that nuclear plant construction in China must be accelerated if the acute shortage of electrical power in the developed industrial areas along China's coastline is to be remedied.

Our inspection tour of nuclear power plant construction in France has convinced us that it is perfectly feasible for China to construct several nuclear power plants with capacities of 10 million kilowatts or more by the year 2000. It has taken France 12 or 13 years to construct the plants that are currently producing 23 million kilowatts. Although conditions in China are different from those in France, China's industrial base is no less favorable than that in France at the beginning of the 1970's. Hence, plans for China to construct nuclear power plants generating 10 million kilowatts or more in the next 17 or 18 years should be feasible. Although the problem of construction funding has been regarded as a serious one in the past, the experience of France, the Soviet Union, Japan, and other countries indicates that the capital investment per kilowatt required by nuclear power plants is generally only 25-35 percent higher than for ordinary power plants. Judging from these figures, China should be able to construct a 1 million kilowatt class nuclear power plant at a unit cost of less than 1,000 yuan per kilowatt provided Chinese-produced equipment is used. This figure is less than the cost of constructing hydroelectric plants in China. Thus, if two 900-megawatt nuclear power plants are to be constructed, the total



required investment will be 2 billion yuan; economically, this is quite reasonable compared with the expense of hauling coal or transmitting electricity over long distances.

2. China must produce its own equipment if nuclear power plants are to be constructed more rapidly.

In order for China's nuclear power industry to develop more quickly it will be necessary to reduce construction costs to below prevailing world levels, and the crucial factor here is to use locally manufactured equipment. Since equipment expenses comprise a very high percentage of the total costs, these costs can be reduced considerably by employing Chinese-produced equipment. Taking the 1982 figures provided by France as an example, we see that equipment costs amount to 63-70 percent of the total construction costs. The high cost of China's nuclear power plant in Guangdong Province derives mainly from the fact that foreign equipment was purchased at the prevailing high international prices. The capital costs of nuclear plant construction will be greatly reduced if we are successful in importing the necessary technology and allocate production capacity so as to make China self-sufficient in equipment as soon as possible.

After the Shanghai Project "728", several of China's largest factories were expanded and rebuilt. In terms of facilities, hoisting power, and available equipment, the manufacturing capability needed to build the equipment for constructing nuclear power plants is already available. I visited several of these factories last April, shortly after a team of specialists from the French firm Alsthom-Atlantique had visited several plants of the Ministry of Machine Building Industry. They concluded that China has the capacity to produce the equipment needed for large-scale nuclear power plants islands of the conventional type (steam turbines rotating at 1500 rpm). If the Shanghai plants are used as a base and China supplies funding, if we fill the gaps in our ability to produce the equipment needed to construct nuclear power plants in the 900-1,300 MW class, and if roughly 5 years are required to assimilate the technology imported from abroad, it should be possible after 2 or 3 years of hard work for China to construct two or three plants per year.

3. Overall planning, concentration, and use of financial resources and materials.

Since our financial resources are limited, assets and materials must be concentrated if the development of China's nuclear power industry is to be accelerated. Again, France serves as a useful model for technical policy, planning, and allocation relating to nuclear power plants. Their example has convinced us that we should utilize the mature technology available from abroad and employ mass production methods making it necessary to map out a well-planned, centralized strategy. We should not attempt to do everything at once, since this will only scatter our investments and cause delays. For now, we should first plan to select several locations well suited for nuclear power plants and concentrate on carrying out the necessary groundwork. Two sets of working plans should be provided for

each plant and they should be constructed first where conditions are most favorable and work can proceed the fastest. This will enable us to concentrate our energy and save time, so that the pace of construction will be quickened.

4. Scientific research in China should be redoubled while foreign technology is imported.

Although France required approximately 10 years to assimilate the technology borrowed from the United States to become self-sufficient in nuclear power plant construction, the situation has changed and France is now exporting its own technical expertise. This is a direct result of their stress on the importance of domestic research. We too must take measures to strengthen research in China in order to assimilate the imported technology more quickly and completely, to ensure that all of the various phases (manufacturing, constructing, equipping, and operating of large-scale nuclear plants) go smoothly, and to permit China's development to proceed more independently. Today, China's scientific and technical personnel have already attained a certain level of expertise, and several experimental research institutes have been formed which will provide a useful basis. Nevertheless, still more is needed, and China must support more research.

5. Adopting a suitable organizational structure to integrate all facets of the work.

Given China's present system, nuclear power plant construction will involve numerous government agencies such as the Ministry of Water Resources and Electric Power, the Ministry of Nuclear Industry, the Ministry of Machine Building, and various high-level academies. This would result in duplication of effort and scattering of resources in research, design, construction, and production of nuclear power plants. I suggest that a single suitably constituted body be formed to coordinate the allocation of resources and avoid unnecessary duplication and buck-passing so that we will be able to forge ahead in nuclear power plant construction.

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CSO: 4013/85

## SUPPLEMENTAL SOURCES

### SYMPOSIUM STRESSES USE OF WIND POWER IN RURAL AREAS

OW080221 Beijing XINHUA Domestic Service in Chinese 1514 GMT 6 Mar 84

[Article by reporter Yu Yuanjiang]

[Text] Beijing, 6 Mar (XINHUA)--It was pointed out at the national symposium to study generation of electricity with small windmill generators that remote mountainous areas, grasslands, deserts and offshore islands, where there is an abundant wind resource and where electricity is unavailable, should pay special attention to generating electricity with windmill generators.

The meeting, which was held in Beijing recently, was cosponsored by the State Scientific and Technological Commission, the Ministry of Water Resources and Electric Power and the Ministry of Machine Building Industry. Addressing the meeting, Yang Jun, vice minister in charge of the State Scientific and Technological Commission, said: Comrades of the central authorities pointed out that, to solve their energy problems, the rural areas should not depend on the state for coal. Not only because the state does not have enough coal, but also because the environment will be polluted if coal is used as fuel everywhere in the rural areas. If the environment there is polluted, the rural areas will become uninhabitable for human beings and animals and unfit for plants. To solve the rural areas' energy problems, therefore, we must rely on such new energy resources as solar energy, wind energy, biomass (including firewood and marsh gas), water energy (including small hydroelectric power stations and tides), geothermal energy and so forth, plus such measures as remodelling stoves and conserving firewood.

Yang Jun said: Of the 800 million peasants in our country, electricity is still unavailable to 300 million of them in the rural areas. Availability of electricity is particularly hard for remote, sparsely populated areas. For these areas, the realistic and feasible approach is to generate electricity with wind and solar power and by building small hydroelectric power stations in the light of these areas' national conditions.

China's wind resources are abundant, being particularly plentiful along the coastal areas and the offshore islands, Nei Monggol, Gansu, northern Xinjiang, Heilongjiang, eastern Jilin and the Qinghai-Xizang Plateau. Wind energy in these areas can be utilized to generate electricity.

The meeting pointed out: To develop windmill power generation, local conditions must be considered. Attention must be directed to developing windmill generators, particularly small ones, which are useful to the vast rural areas and are affordable by them. At the same time, relevant technical problems must also be properly resolved and the quality of generators must be ensured. Moreover, products must be standardized and systemized, and attention must also be directed to development and production of auxiliary equipment. Efforts must also be made to train technicians so that needed services will be available during the development of this type of power generation.

The meeting pointed out that development of wind power generation should primarily be sponsored by the people themselves, and that the main purpose of such a project is to solve their ordinary needs. It added: While a collective unit may sponsor its own windmill generator as long as it can afford and take care of it. Sentry posts along the border areas, radar stations, and meteorological stations should also be encouraged to generate electricity with windmill generators.

CSO: 4013/119

## SUPPLEMENTAL SOURCES

### CHINA'S SOLAR ENERGY RESOURCE DISTRIBUTION ANALYZED

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 4, No 3, 25 Jul 83 pp 221-228

[Article by Wang Bingzhong [3769, 3521, 1813], Academy of Meteorological Science, State Meteorological Bureau: "Solar Energy Resource Division in China"; paper received on 15 November 1982]

#### [Excerpt] Abstract

In order to facilitate the exploitation and utilization of China's solar energy, this paper divides the nation's solar energy resources into three levels. The first-level index is the annual value of solar energy resources. The second-level index is the distribution of months with maximum and minimum days of sunshine hours  $\geq 6$  hours. The third-level index is the favorable period of solar energy utilization during the day. Solar energy resource division maps and the division characteristic tables are given.

The solar energy distribution maps only reflect an average condition over many years. If one intends to fully utilize the solar energy resource locally, one must make note of daily and yearly variations.

The distribution of solar energy resources is obviously localized. Such a pattern mainly reflects the constraints on solar radiation due to weather and environmental conditions. Based on the actual conditions in our country, we used the three-level division system to divide the solar energy resources in the nation into 30 regions or subregions.

The division index of the first level is the annual amount of solar energy resources. Based on the amount of annual solar energy, we divided the country into four belts.<sup>(1)</sup> The specific division standards are:

<u>Name</u>	<u>Symbol</u>	
abundant belt	I	$>150 \text{ kcal/cm}^2 \text{ year}$
relatively abundant belt	II	$120-150 \text{ kcal/cm}^2 \text{ year}$
relatively poor belt	III	$100-120 \text{ kcal/cm}^2 \text{ year}$
poor belt	IV	$<100 \text{ kcal/cm}^2 \text{ year}$

However, in addition to the total amount of resources, it is also necessary to understand the seasonal distribution in specific applications, as it will frequently affect the useability and efficiency of the resources directly. For this reason, we statistically computed the number of days in each month with more than 6 hours of sunshine based on the daily records of nearly 200 meteorological stations from 1971-1980.\* The statistical results are shown in Table 1. From this one can see that the distribution of months with maximum and minimum days is obviously regional (Figures 1 and 2). It actually reflects the favorable and unfavorable seasons for solar energy utilization locally. Based on this fact, we chose it as the second-level index. The numerator is used to express the season having the maximum number of days, which is the season favorable for solar energy utilization. The denominator is used to express the season with the minimum number of days which is the season unfavorable for solar energy utilization.

The first letters of the pinyin equivalents are used as follows:

Spring (March-May)	Chun	C
Summer (June-August)	Xia	X
Fall (September-November)	Qiu	Q
Winter (December-February)	Dong	D

Table 1. Number of days a month with  $\geq 6$  hours of sunshine

Name of Station	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Harbin	23.0	21.9	24.9	22.6	22.5	21.7	23.3	22.9	21.5	20.5	18.7	17.5
Xilin Hot	23.3	22.4	24.7	24.2	24.8	23.4	23.2	23.4	23.1	23.9	22.1	21.7
Beijing	22.9	20.2	23.0	23.9	26.9	21.0	18.9	21.2	23.1	24.1	21.2	21.9
Zhengzhou	16.2	14.7	16.0	18.2	21.4	21.2	18.8	19.6	17.9	19.7	18.2	17.1
Wenzhou	12.0	10.1	10.0	10.5	8.3	11.2	22.2	20.4	17.0	15.7	15.1	15.2
Nanchang	9.8	8.8	7.8	10.4	10.6	13.9	23.3	22.6	17.2	17.4	16.0	14.2
Shantou	13.0	9.4	9.2	10.0	9.1	14.1	22.1	20.7	20.8	19.5	18.3	16.8
Xi'an	13.1	11.9	14.2	15.7	16.3	17.9	19.7	20.6	12.9	15.4	12.7	10.4
Chongqing	1.1	1.7	6.3	8.0	7.5	8.5	17.4	19.4	9.0	6.6	3.5	1.0
Nanning	6.9	6.5	6.3	6.7	14.6	16.1	20.7	16.2	20.2	15.8	16.3	12.3

\*For solar energy utilization, it is commonly held that when a day has 6 hours or more of sunshine, it may be used for solar energy; anything less than 6 hours is considered unuseable.

Dunhuang	23.5	22.6	25.2	25.7	27.6	25.6	26.6	27.1	26.7	28.4	25.6	23.8
Xining	24.5	22.5	23.6	24.6	24.2	23.2	22.0	22.4	18.1	22.8	24.8	24.2
Hami	25.4	24.6	26.9	26.3	28.6	26.8	27.9	28.1	27.7	28.9	25.2	24.0
Lhasa	27.0	22.8	25.7	25.6	27.5	23.6	19.9	21.7	22.9	26.9	28.5	28.6
Changdu	19.9	17.0	17.4	18.3	20.2	18.1	16.3	18.3	17.3	19.4	22.8	22.1
Xichang	25.2	23.3	26.7	24.6	20.3	13.5	17.3	18.7	12.9	13.8	17.7	22.5
Kunming	21.7	20.8	24.5	22.8	17.6	9.2	11.1	12.3	9.4	13.6	13.9	20.8
Simao	25.0	23.7	26.1	23.1	16.8	6.6	7.6	7.4	11.2	13.9	14.1	20.7

The ratio of the maximum and minimum number of days can be taken as a local index of the variation of solar energy resources over the year. Obviously, the smaller this ratio is, the more it favors solar energy utilization (Figure 3). Nationally, in the region north to 30° north latitude, this ratio is basically less than 2. It is below 1.2 in middle-western New Monggol, which is the region most favorable to the utilization of solar energy. In the Sichuan Basin and Southwestern Yunnan on the Sino-Burmese border, this value is above 4. It is the solar energy resource poor region and most difficult for its utilization. The distribution of the total annual number of days with sunshine hours  $\geq 6$  hours is shown in Figure 4. Because it is approximately the same as the distribution of solar energy resources, no first-level division index was made.

In addition, conventional solar energy hot water heaters can function normally in months with an average temperature  $\geq 10^{\circ}\text{C}$ . We also carried out statistical analyses on the total number of days with  $\geq 6$  hours of sunshine within this time period, with distribution as shown in Figure 5. However, it is necessary to explain that the numbers in Figure 5 are somewhat rough as the concept of monthly average temperature  $\geq 10^{\circ}\text{C}$  contains different contents. For example, the average temperature in April at a certain station is  $9.9^{\circ}\text{C}$ . Here, even though there were many days when the temperature was higher than  $10^{\circ}\text{C}$  and when there were more than 6 hours of sunshine, they were not included in the statistics. Conversely, if the average temperature was  $10.1^{\circ}\text{C}$  in April at a certain station, even when the temperature was lower than  $10^{\circ}\text{C}$  on some of these days, as long as there were more than 6 hours of sunlight, they were included in the statistics. In other words, the daily temperature was not considered when carrying out the sunshine hour statistics. After the statistics had been completed, the criterion of whether the monthly average temperature satisfied  $\geq 10^{\circ}\text{C}$  was used to determine whether this month would be included in the total number of days accumulated. Caution should be exercised when using this figure.

In the utilization of solar energy, the pattern of variation of sunshine during a day is also important. However, it is very difficult to find an index to characterize this daily variation. First of all, we do not have an

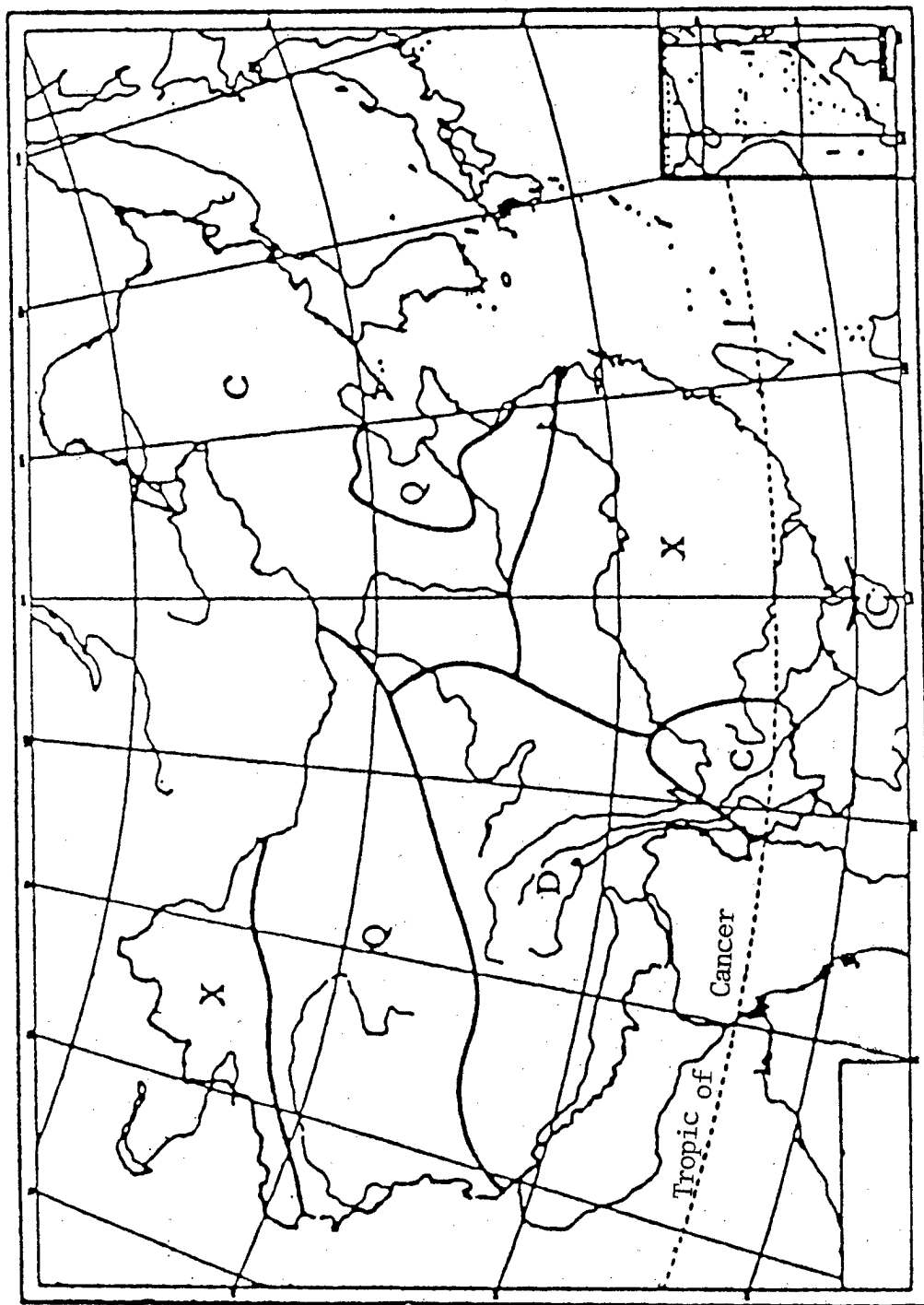


Figure 1. Regional Distribution of Months With Maximum Number of Days With Sunshine Hours  $\geq 6$  Hours.



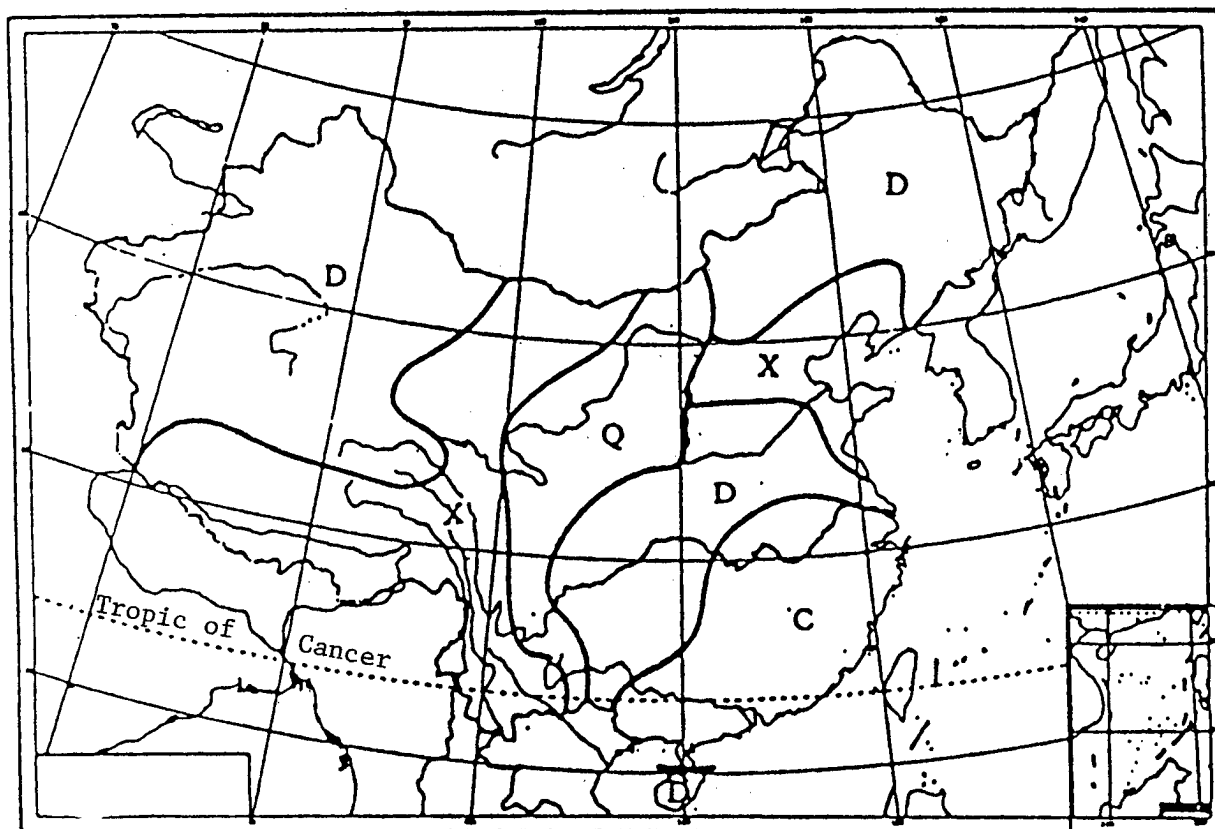


Figure 2. Regional Distribution Months With Least Number of Days Having  $\geq 6$  Hours of Sunshine.

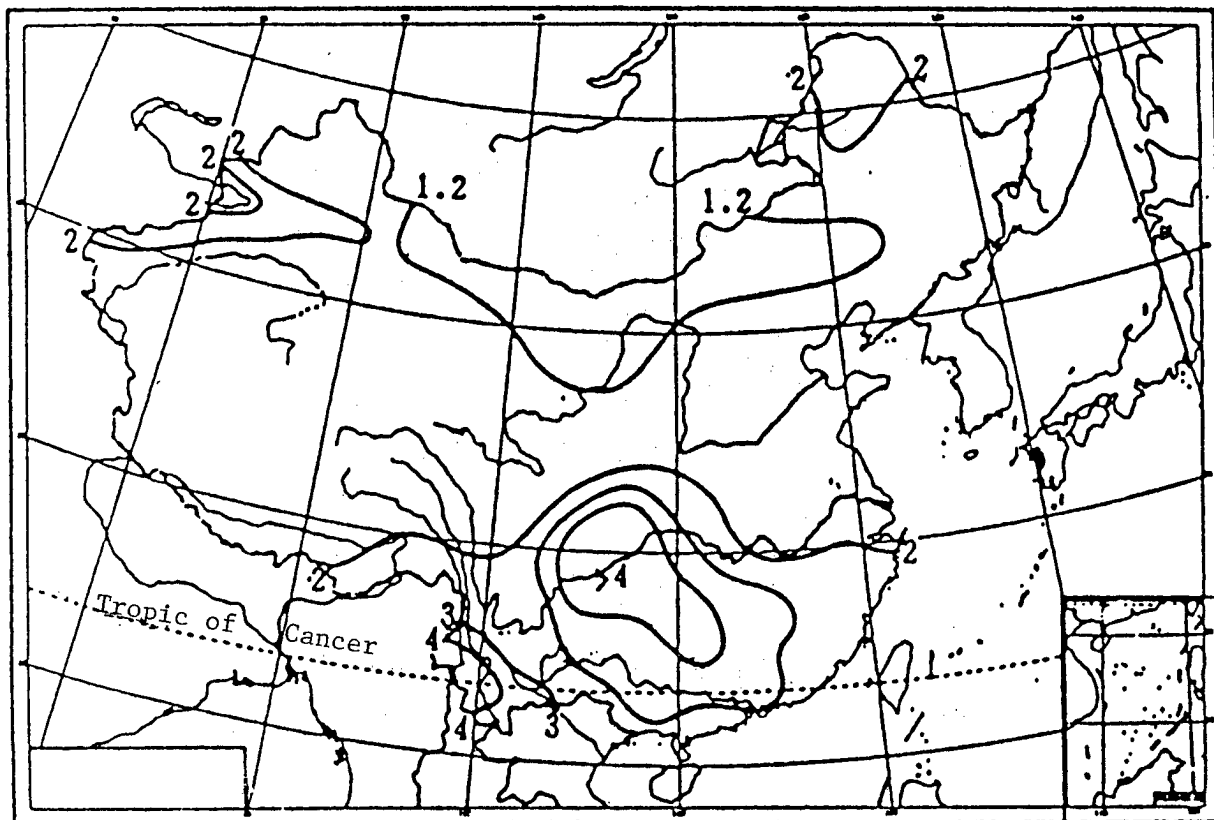


Figure 3. Ratio of Maximum and Minimum Number of Days With  $\geq 6$  Hours of Sunshine a Month.

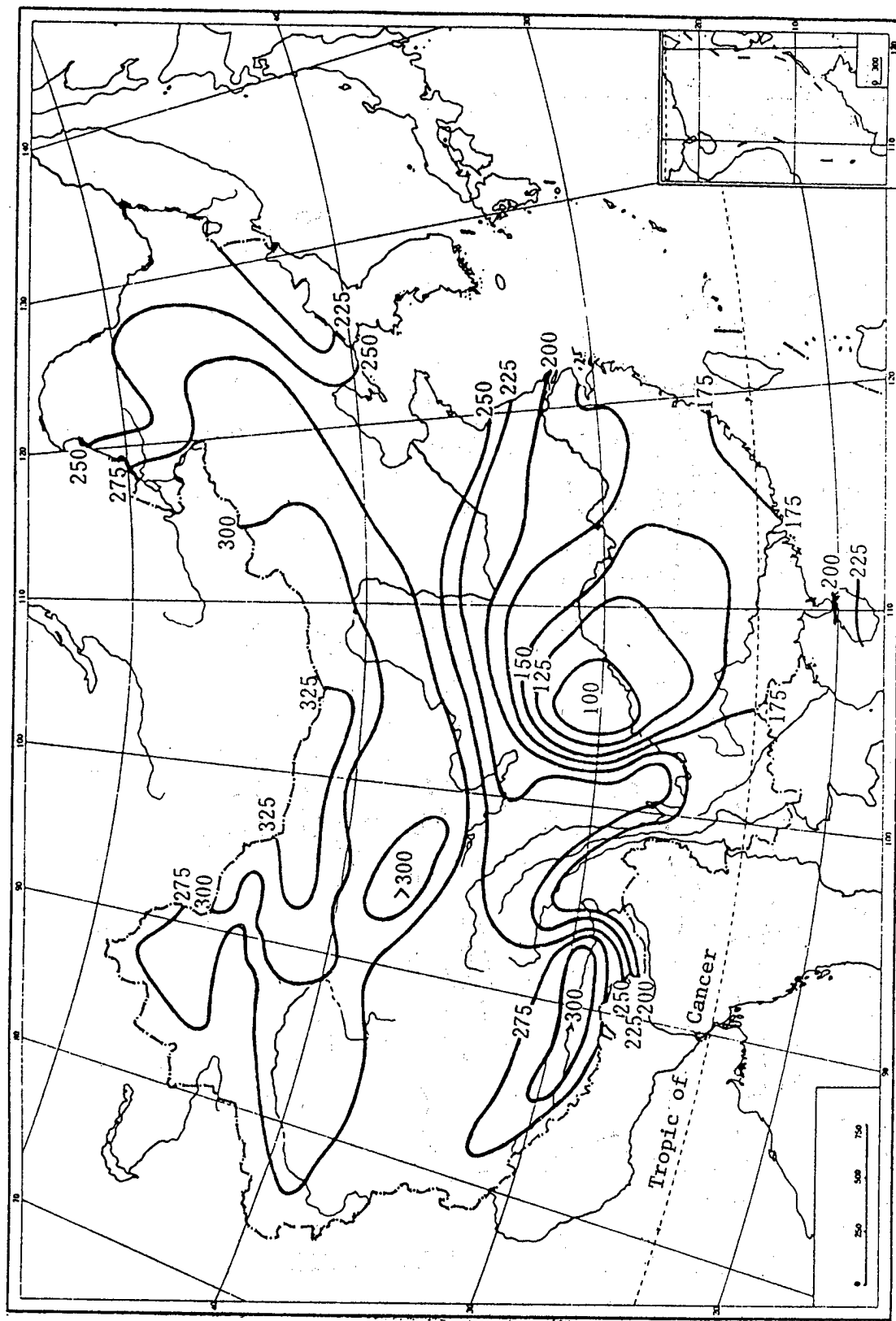


Figure 4. Distribution of Total Days a Year With  $\geq 6$  Hours of Sunshine.

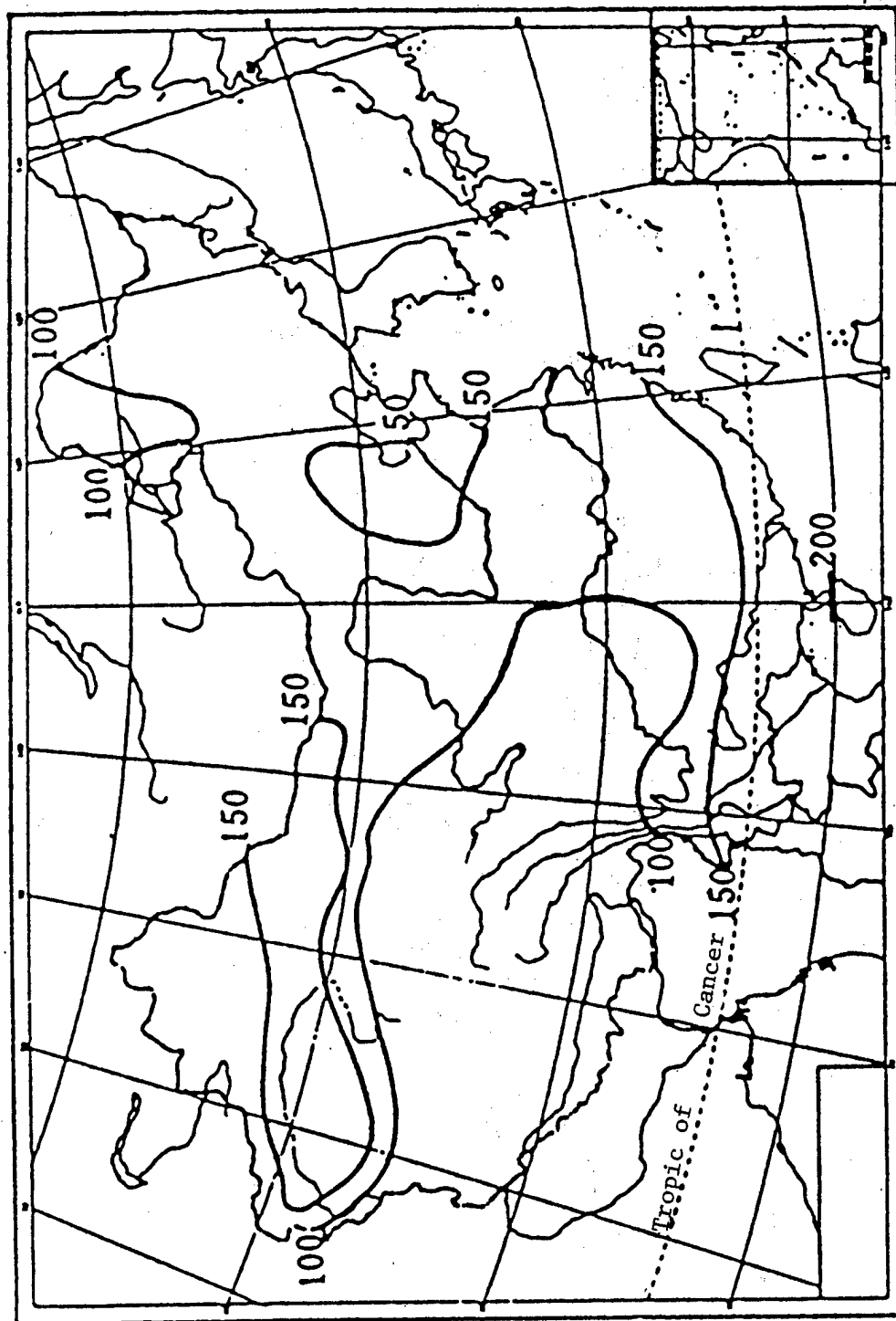


Figure 5. Total Number of Days  $\geq 6$  Hours of Sunshine in Monthly Average Temperature  $\geq 10^{\circ}\text{C}$  Periods.

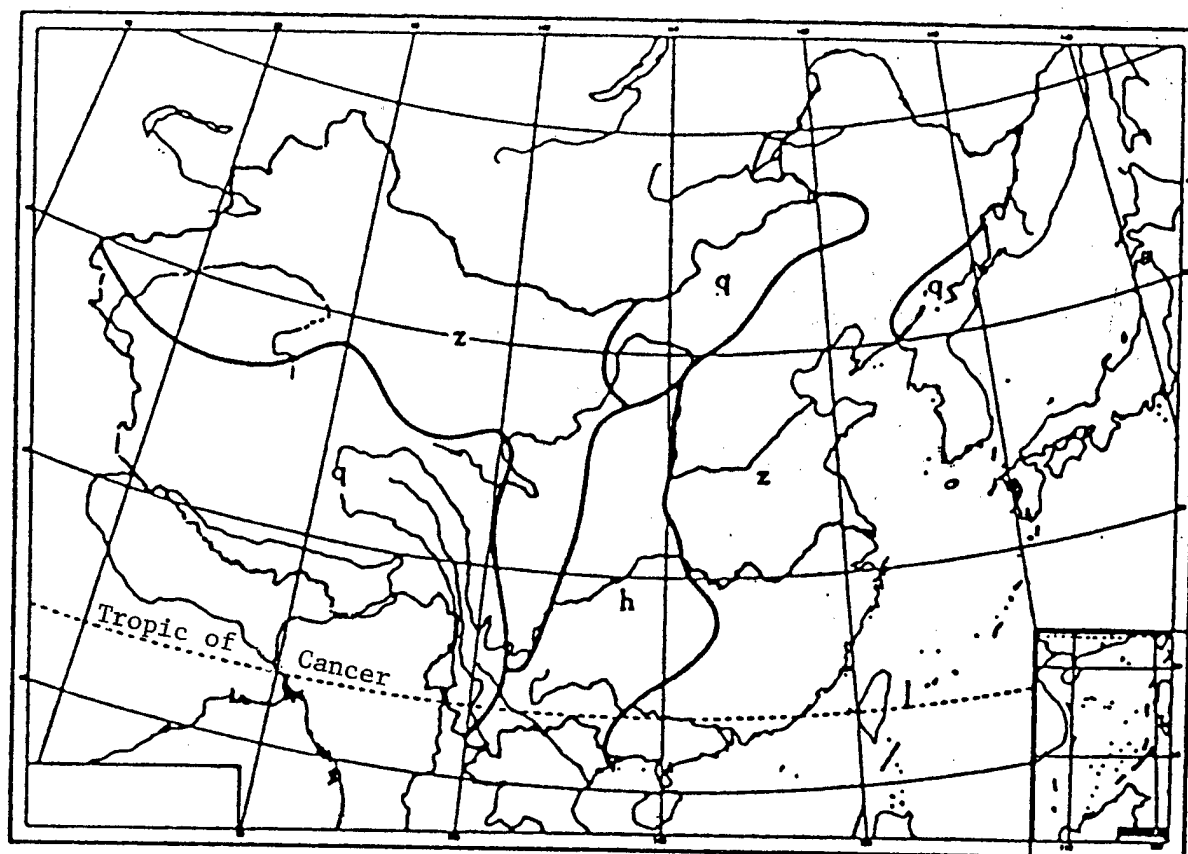


Figure 6. Daily Distribution Map of Sunshine Hours.



automatic record of solar radiation in our country over a long period of time. Next, sunrise and sunset vary not only according to the season, but also depending on the location. Furthermore, there is variation for the same location. In order to overcome such difficulties, we decided to use the annual average sunshine hours between 0900-1000 hrs (local solar time, same below) to represent morning sunshine, between 1100-1300 hrs as the noon sunshine and 1400-1500 hrs as the afternoon sunshine. Based on this, the automatically recorded sunshine data of nearly 200 stations all over the country were arranged. When the average annual sunshine hour is longer in one period, it shows that this time period favors solar energy utilization (for ease of comparison, the hours in noon periods were divided by 2). Again, the symbols used are from the pinyin alphabet. In order to avoid repetition, morning is referred to as "before noon," represented by "qian." "Afternoon" is represented by "hou."

before (morning)	qian	q
middle (noon)	zhong	z
after (afternoon)	hou	h

The regional solar energy distribution pattern is shown in Figure 6.

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CSO: 4013/19

## CONSERVATION

### CONSERVATION EFFORT SAVES EQUIVALENT OF 70 MILLION TONS OF COAL

OW281710 Beijing XINHUA in English 1511 GMT 22 Feb 84

[Text] Beijing, 22 February (XINHUA)--China has saved energy equivalent to 70 million tons of coal in the past 3 years, the State Economic Commission announced today in a release to a national economic conference now in session here.

The Commission attributed the achievement to upgrading of industrial equipment and technology, and improved enterprise management.

China plans to save energy equivalent to 18 million tons of coal this year, according to the release. Facilities capable of conserving 5.06 million tons will be completed nationwide.

Energy conservation progress has been reported from the metallurgical, chemical, power, and building material industries.

The country's coke consumption per ton of steel dropped 0.134 of a ton in 1982 compared to 1980, decreasing at an annual rate of 3.45 percent. In Liaoning Province, the Anshan Iron and Steel Company, China's largest, consumed 994 kilograms of coke per ton of steel last year, a decrease of 34 kilograms compared to 1982.

Energy consumption in Shanghai, Tianjin, and Jiangsu and Zhejiang provinces for the manufacture of products worth 100 million yuan (about 50 million U.S. dollars) is only half of the amount recorded nationwide.

Shanghai, China's largest industrial city, saved energy equivalent to 640,000 tons of coal in 1983, including 450 million kilowatt-hours of electricity, 57,000 tons of fuel oil and 28,000 tons of coke.

Energy conservation is being given top priority in China's economic construction, according to the State Economic Commission's release. The country's industrial output value increased at an annual average rate of 7.3 percent between 1981 and 1983, while its energy production rose 3.3 percent annually.

CSO: 4013/119



## CONSERVATION

### HEAT AND POWER COGENERATION: PARTIAL SOLUTION TO ENERGY SHORTAGE

Taiyuan JISHU JINGJI YU GUANLI YANJIU [RESEARCH ON THE ECONOMICS AND MANAGEMENT OF TECHNOLOGY] in Chinese No 3, 30 Sep 83 pp 38, 39

[Article by Liu Daiqi [0491 0108 3825]: "Heat and Power Cogeneration and Centralized Heat Supply"]

[Text] To resolve the problem of the energy shortage now and in the future, China's policy is to emphasize both development and economizing, but in the near term, economizing should be the highest priority. The first thing in saving energy is fully utilizing and developing its potential, economizing at every link from energy production to consumption to improve the effective utilization ratio.

Heat and power cogeneration and centralized heat supply are important measures for saving energy.

#### 1. What is heat and power cogeneration?

Simply stated, it is using the steam turbine generators of thermal power plants both for generating electricity and for supplying heat. We usually call such power plants heat and power plants. The steam produced in high-pressure, high-temperature boilers of heat and power plants is first used to operate the turbines which drive the generators to generate power, and when finished, the remaining steam, with its temperature lowered (usually below 250° C), is piped directly to other plants and customers to be used in production or for residential heating. The heat from the water as it cools is wholly or partially recovered for use. This is one way of killing two birds with one stone. Heat and power plants built in Shanxi Province since Liberation are the Taiyuan No 1 and No 2 heat and power plants and the Datong Heat and Power Plant.

#### 2. What is centralized heat supply?

The heat and power cogeneration discussed above is one method of centralized heat supply, one which can be used only in regions having suitable conditions for the construction of heat and power plants. Regions which do not have heat and power plants or which do not have suitable conditions may consider installation of large capacity, high-efficiency, large-scale national boiler

rooms supplying heat through heating pipes to thousands of customers for residential heating as well as for production in factories. This centralized heat supply method can replace individual scattered and backward small boilers. For this reason, centralized heat supply may be called a product of large-scale socialized production, and is a necessary trend of social development and scientific and technological development.

3. What are the advantages of heat and power cogeneration and centralized heat supply?

1) A large amount of energy can be saved. This is because the highest temperature which can be produced when coal is burned is above 1000 degrees but in ordinary industrial boilers and heating boilers, it only produces steam and hot water of 100-200 degrees and cannot make full use of the coal. Based on what is known of the approximately 200,000 small boilers of various types in China now, the annual average necessary raw coal consumption is over 200 million tons; consumption of raw coal for domestic heating and cooking is 120 million tons, or a rather large proportion of national coal consumption. For this reason, if centralized heat supply can be widely adopted to a sufficient degree and new high-capacity, high-efficiency, high-parameter, large-scale boilers gradually replace the present simple, old fashioned small-capacity, low-efficiency, and low-parameter small boilers --the "coal hogs"--can be for the most part abolished, saving greatly on raw coal and opening a new path for future energy conservation.

2) The efficiency of thermal energy can be improved.

Since heat and power cogeneration produces power and supplies heat, fully utilizing low energy steam as well as guaranteeing heat for customers' production and residential use, it realizes energy use according to quality, reduces the unavoidable condensation point loss of condenser type power plants, and improves the utilization ratio of thermal energy from power plants. The highest heat efficiency rate of existing large-scale condenser type generators is about 40 percent, the heat efficiency rate of heat supply generators can reach 85 percent, the heat efficiency rate of regional boiler rooms can reach 90 percent, the heat efficiency rate of scattered small-scale boilers is generally only 50-60 percent, and the heat efficiency rate of boilers for civil use is only about 20 percent.

3) It is good for environmental protection.

Adoption of either heat and power cogeneration or regional boiler room centralized heat supply can greatly improve the environment. Pollution from exhaust gases and ash is reduced, improving urban air quality. Large-scale boilers can use high-efficiency scrubbers and tall smokestacks dilute and disperse coal smoke and ash, reducing harmful air pollution in the cities and protecting the physical health of the people.

4) It improves working conditions and saves labor.

Large-scale boilers can be mechanized. Heat and power plants can use mechanized and automated equipment to control operations from moving and stoking the coal to removing ash, replacing strenuous manual labor, improving work conditions, and saving labor.

5) Heat and power plants can burn many types of low quality coal, such as such as gangue. In this way high-quality coal and lump coal can be saved for other industrial uses or for export for foreign exchange, while at the same time taking care of the large quantity of low-grade coal which has accumulated at coal mines.

4. Where can heat and power cogeneration and centralized heat supply be extended?

1) Cities and towns where local industry is well developed and where there are numerous medium- and small-scale productive enterprises, and areas where there is a fixed number of customers for heat supply and where the winter heating season requires a large amount of heat to supply heating customers, have these conditions.

2) Newly constructed industrial areas and residential areas should certainly change the scattered and backward heating method of one boiler for each unit and adopt instead heat and power cogeneration or regional large-scale boiler centralized heat supply to resolve the problems of industrial production and domestic heating.

3) In places where conditions exist, present condenser type generators in cities or in suburban areas should be converted to regional heat and power supply stations. This is the most effective method for low investment and quick results. At present, Shanxi Province's Yongji Power Plant, and the Datong Pingwang Power Plant are both beginning to consider converting old plant equipment or expanding heat supply generators to resolve the problem of heat supply for the region.

4) In small cities and towns where the conditions exist for building mine-mouth power plants and there is a definite heat load, when beginning construction of a power plant it should be combined with heat and power cogeneration and centralized heat supply be considered. The optimum steam heat supply radius is no greater than 2-3 km. This reduces heat loss to a minimum, reduces the heating pipeline, saves on steel, and saves on the expenses of transport and maintenance. Yet the heat supply radius of large-scale power stations abroad which use hot water for heat supply can reach 10-20 km.

5. How are heating proposals selected and settled on?

The prerequisite for city and town heating first of all requires calculating whether or not the industrial area has a definite and relatively stable heat load, then, on the basis of the quality, size, and economic nature of the heat load, the most ideal heating proposal is selected. Before settling on a proposal, first carry out feasibility studies, compare many proposals,

and, on the basis of specific conditions, considering principles of suitability to local conditions then decide whether to construct a heat and power station or be a regional boiler room or prefabricated small boiler room.

Below is a brief introduction to several kinds of centralized heat supply:

1) Heat supply using a back-pressure type turbine. The back-pressure turbine has no condensation point loss, steam exhaust is generally at 2-4 ata, and generally can all be used. It is characterized by the fact that power is determined by heat: the steam turbine generator generates electricity in direct proportion to the volume of heat supplied, and when the heat supply drops to a certain volume, it will not operate. For this reason, when there is a fixed and large volume heat load, using a back-pressure steam turbine generator is ideal heat and power cogeneration.

2) Heat supply using a bleeder turbine. This is a generator which supplies both heat and power, heat supply (bleeding) and power generation can be independent. When the heat supply volume achieves a specific value, it will operate under most economic conditions. When power generation is greater than heat supply, though it is less economical, it is not unable to operate, as is the case with the back-pressure turbine. For this reason, when the heat load becomes greater or unstable, (as in seasonal heat supply) it is better to use the bleeder turbine.

3) Heat supply using a regional boiler room. In areas where it is not appropriate to use heat and power cogeneration, centralized heat supply using a regional boiler room has the greater superiority for saving on coal and reducing environmental pollution.

4) Utilizing and transforming existing medium- and small-scale power plants. With the development of the electric power industry, large-scale power plants are gradually increasing and with the expansion of power networks, some medium- and small-scale power plants will be eliminated due to their rather low economic value, but if these power plants are less than 2-4 km from a heat load center, with transformation of the existing equipment using higher bleeding pressure, raising the exit temperature of cooling water, and utilizing cyclical water heat supply, the hot water temperature can average between 60° and 70° C and can satisfy demands for winter heating.

The above methods are more advantageous than using scattered small-scale boilers. Heat and power cogeneration and centralized heat supply already have precedents domestically and abroad and in addition have already proved to be very energy efficient. Heat and power cogeneration should be considered from the perspective of comprehensive utilization of energy sources, and the economic results, calculated in terms of unit benefits, should be greater.

China's present energy utilization efficiency rate is only 28-30 percent and abroad it is generally about 55 percent. For this reason, China's energy saving potential is still very great. Accelerating the development of urban heating will become an effective measure for energy use and energy saving and should receive adequate attention.